St. Lawrence
Vision 2000

Health and the St. Lawrence

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Foreword

The St. Lawrence has a central place in Quebec society as much for the human activities it supports as for its rich natural capital. However, for several years now the St. Lawrence has suffered from the spread of information concerning its chemical and microbiological contamination as well as deterioration in the quality of its resources. Over the years, the public has stopped doing activities on the St. Lawrence – due to the real danger, a lack of confidence or a growing accessibility to other leisure activities. Moreover, riverside residents have gradually been deprived of numerous access points to the river for activities such as swimming and fishing.

The implementation of various initiatives such as the St. Lawrence Action Plan have allowed great improvements to the situation, most notably by eliminating a significant number of toxic emission sources into the river. Despite these improvements, additional effort must be made. Indeed, contaminants are still detected in some of the St. Lawrence's most sought-after resources by fishers and mollusk harvesters. Some sectors of the St. Lawrence offering attractive potential for water-based activities are still facing microbiological contamination.

In this context, what do we know about the human health risks associated with contact with the St. Lawrence? What actions have been undertaken to improve knowledge on the subject? What changes are we seeing in the behaviour of riverside residents with respect to recreational activities being practised on the St. Lawrence? What measures should be implemented to further reduce health risks associated with these activities?

Since 1993, Health Canada and the *Ministère de la Santé et des Services sociaux du Québec* have been working to clarify the relationship between the St. Lawrence and human health. Activities of the Human Health Component aim to answer questions from the public and provide information that is as accurate as possible. Numerous activities focusing on research, monitoring, communication, evaluation and promotion measures have been undertaken by professionals from Quebec's public health network or research centres, in cooperation with community groups involved in St. Lawrence Vision 2000.

Since 1998, significant efforts have been made to support projects within a community perspective. Several committees in the Areas of Prime Concern (*zones d'intervention prioritaire* or ZIP committees), whose work focuses on the St. Lawrence, were encouraged to present projects to inform the public about health and appropriate uses of the St. Lawrence. Other organizations, groups working in the field and even individuals worked closely on a variety of activities. These partners included CLSCs, hospitals, municipalities, fishing and hunting associations, mollusk producers and even boat owners.

If much has been accomplished to restore the St. Lawrence, efforts must be continued to maintain these improvements. The federal and provincial governments agree to develop a more integrated management approach for the St. Lawrence, which will require the involvement of all stakeholders. This approach will be based, among other things, on principles outlined in the recently adopted *Quebec Water Policy* and the federal *Oceans Act*, which recommend integrated management within a sustainable development perspective.

We sincerely hope these efforts will allow the St. Lawrence to gradually recapture its rightful place in riverside residents' daily lives.

It is with great enthusiasm that we present *The St. Lawrence and Human Health, Status Report II*, a summary of the main research undertaken since 1993 within St. Lawrence Vision 2000's Human Health Component.

Michèle Bélanger
Co-chair
Human Health Component
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Introduction

The St. Lawrence is among the largest rivers in the world. Besides its great length, along with the surface area of its drainage basin and its average discharge, the St. Lawrence is particularly recognized for the low population density along its banks, which makes it an enviable place due to the availability of its water-based resources. An outlet of the Great Lakes, it runs several hundred kilometres before reaching the Gulf of St. Lawrence and then the Atlantic Ocean. In its upper reaches, it is a freshwater river made up of areas of rapid flow and vast lakeside expanses. Its waters become brackish a little downstream from Quebec City and saltier as it flows farther east.

For centuries this natural milieu, rich in resources and diversified habitats, has also been an essential artery contributing to the country's development. The St. Lawrence is an important maritime seaway travelled by commercial ships and numerous pleasure craft. Most of the province's agricultural land is found close by and along its tributaries. The St. Lawrence provides more than a third of Quebec's population with drinking water and is also a favourite spot for a variety of recreational activities including fishing, mollusk harvesting, hunting, water sports and swimming.

THE HUMAN HEALTH COMPONENT OF ST. LAWRENCE VISION 2000

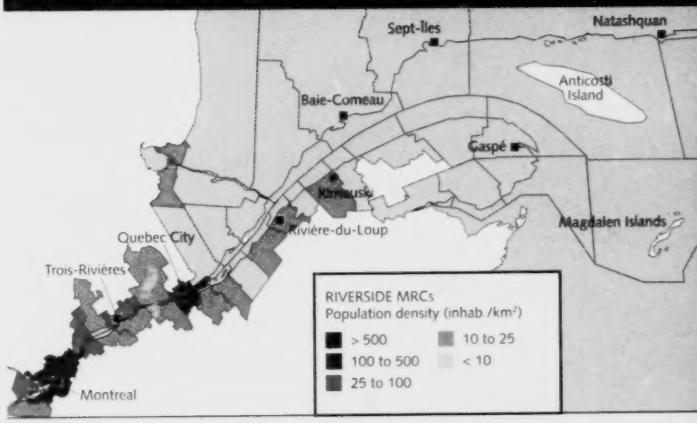
In June 1989, ten years after the start of the *Programme d'assainissement des eaux du Québec* (Quebec wastewater treatment program), the Canadian and Quebec governments signed an agreement to protect, conserve and restore the water quality of the St. Lawrence. This agreement, the St. Lawrence Action Plan, covered the period from 1988 to 1993. It was first renewed until 1998 through the development of a second phase, St. Lawrence Vision 2000 (SLV 2000). To respond to growing public health concerns relating to the state of the St. Lawrence, a health component (later called the *Human Health Component*), managed jointly by Health Canada and the *Ministère de la Santé et des Services sociaux du Québec*, was integrated into the program's other areas of intervention. The agreement was extended a second time, until 2003, during which three major objectives were set: protection of the ecosystem's health, protection of human health and involvement of communities along the St. Lawrence to promote accessibility and renew river-related activities.

The specific objectives of the Human Health Component were as follows: obtain a portrait of the sources of contaminants present in the St. Lawrence and the degree of exposure among riverside residents; establish the extent of health risks associated with exposure to these contaminants and gain a better understanding of public concerns in this regard; and finally to promote the reduction of public exposure to different sources of contaminants in the St. Lawrence.

To attain these objectives, various organizations and concerned individuals resorted to a wide range of methods and appropriate tools. Many disciplines including epidemiology, toxicology, microbiology, social sciences and communications were put to use in conducting research, monitoring, evaluation and informational activities.

This document is a synthesis of current knowledge concerning the impact of the St. Lawrence on the health of its users and riverside residents. It is divided in three parts: the St. Lawrence River as a source of food, water-based activities, and the supply of drinking water. The document draws attention to highlights from most studies and other initiatives of the Human Health Component, under the St. Lawrence Vision 2000 Action Plan.

POPULATION DENSITY ALONG THE ST. LAWRENCE



Adapted from: St. Lawrence Centre. 1997. "The St. Lawrence River – Riverside population (1994)", in *The River at a Glance*. (Environment Canada – Quebec Region. Info-Flash on the state of the St. Lawrence River). Page 2.

POPULATION DENSITY ALONG THE ST. LAWRENCE

DENIS CHAMARD, FISHERIES AND OCEANS CANADA

1

St. Lawrence River as a source of food

1.1 Sport fishing

For many Quebecers, sport fishing is a recreational activity that is associated with quality of life, particularly for the relaxation that comes with it and the pleasure of being active and in the outdoors.

A 2002 survey found that 287 000 people, or approximately 10% of the St. Lawrence riverside resident population, fish for sport in the St. Lawrence. The largest proportion of those who fish are found in the Gulf region (18%). However, in absolute numbers, sport fishers who fish in the St. Lawrence are found particularly in the freshwater areas (206 892 fishers in 2002).[1]

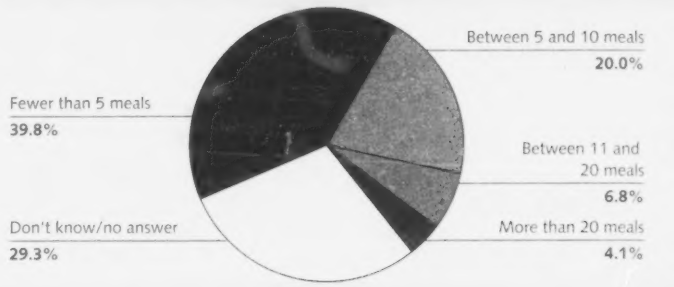
Over the past several years ice fishing has become increasingly popular, particularly in the Saguenay fjord, as well as around Montreal and Lake Saint-Pierre.[2] Approximately 79 000 people (slightly less than 3% of the riverside population) ice fish in the St. Lawrence.[1]

The main species fished in the fresh water part of the River are yellow perch, northern pike, walleye and smallmouth bass. In the upper estuary and the lower estuary, walleye and trout (at the mouth of the rivers) are highly sought after by fishers. In the Gulf area, sport fishing focuses mainly on sea trout, smelt and mackerel.[1]

DO SPORT FISHERS EAT FISH FROM THE ST. LAWRENCE?

Sport fishers consume relatively little of the fish they catch in the St. Lawrence. Indeed, the largest proportion (approximately 40%) eat fewer than five meals of fish over the course of a year while the proportion of anglers who consume more than 20 meals of fish is approximately 4%. Those who eat the most fish caught in the River are found mainly in the Gulf, where 23% eat more than 11 meals of fish per year, compared with 3% of those in the Montreal region.[1]

PROPORTION OF SPORT FISHERS CONSUMING FISH CAUGHT IN THE ST. LAWRENCE BASED ON NUMBER OF MEALS IN 2001[1]



Approximately 287 000 people sport fish in the St. Lawrence.

IMPACT OF SPORT FISHING ON THE UNDERPRIVILEGED[3]

Many past investigations have shown the benefits of outdoor activities. An exploratory study on the impact of river fishing by underprivileged people in Montreal demonstrated that this group does not rely on fishing to sustain itself. An analysis of the interviews conducted with groups who benefited from organized days of river fishing indicated that numerous constraints limit this population from fishing but indicated that fishing can have notable social, psychological and physical impacts when it is organized and supported by community workers.

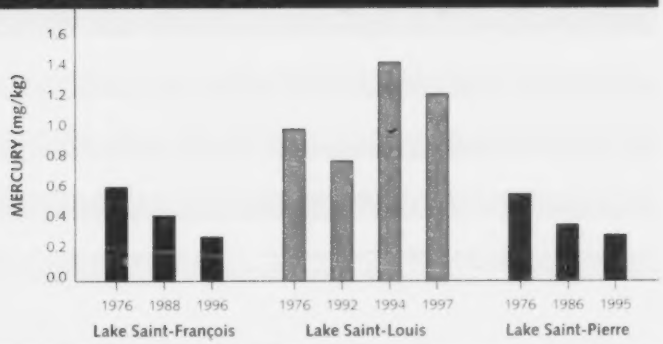
Thus, given the fact that fishing does not play an important part in their daily lives, underprivileged people living in urban areas are not really concerned with the impact that consuming aquatic resources from the St. Lawrence will have on their health. However, when fishing is promoted to these groups, it has a positive psychosocial impact on them.

WHAT DO WE KNOW ABOUT THE QUALITY OF THE FISH THAT ARE CAUGHT?

Since the 1970s data generally indicates that the contamination level of fish in the St. Lawrence has decreased considerably, even if chemical contaminants can still be detected.[4] Mercury and polychlorinated biphenyls (PCBs) are two widely spread toxic chemicals in the environment. Their concentration in fish is an indicator of the state of contamination of the surroundings.

For example, among northern pike, an appealing ichthyophagous (fish-eating fish) to sport fishers, data mainly indicates a mean concentration of mercury below Health Canada's fish commercialization guidelines (0.5 mg/kg). However, higher average values have been observed in Lake Saint-Louis. In addition, individual concentrations in excess of guideline levels have been seen among older specimens.[4]

AVERAGE MERCURY CONCENTRATION IN THE FLESH OF NORTHERN PIKE BY YEAR AND SAMPLING AREA



Adapted from: Painchaud, J. and D. Laliberté, 2002. *La contamination des poissons d'eau douce par les toxiques - Fiche d'information*. Direction du suivi de l'État de l'environnement, ministère de l'Environnement du Québec, St. Lawrence Vision 2000. 6 p.

In terms of PCB in the flesh of fish found in the St. Lawrence, average levels observed in the various species and size categories are generally significantly below the federal commercialization guidelines (2.0 mg/kg).

RECOMMENDATIONS FOR CONSUMING FISH FROM SPORT FISHING

The main recommendations for fish consumption from sport fishing and its effect on health are summarized in the brochure *Heard of Omega-3? I have ...and I'm good for you!*, available on the *Ministère de la Santé et des Services sociaux* Web site (www.msss.gouv.qc.ca).[5] More precise information concerning recommended monthly consumption of Quebec freshwater fish is also available on the Internet at: www.menv.gouv.qc.ca. Recommendations for information purposes for a given area (lake, river) take into account factors affecting the degree of contamination of the fish flesh, including the type of food (ichtyophagous, insectivorous, benthivore) and the size (small, medium, large).

WHAT ARE THE RISKS ASSOCIATED WITH CONSUMING FISH?

The best way to estimate the risks associated with consuming fish and other aquatic products from the St. Lawrence is to measure the contaminant concentration, or that of one of its by-products, in the blood, hair, urine, or breast milk of people consuming these resources and then to compare them with acceptable contaminant concentrations levels. Studies in Quebec have shown that those who consume great quantities of fish from the St. Lawrence have a higher exposure to organochlorines[a] (PCBs, DDT, Chlordane, Mirex, etc.) and to mercury than those who eat small quantities.[6, 7]

[a] *Wide category of contaminants including all organic derivatives where one or more hydrogen atoms were replaced by chlorine atoms.*

SPORT FISHERS IN THE MONTREAL REGION[8]

A series of studies of the risk and benefits of consuming fish from the St. Lawrence was undertaken among sports fishers in the greater Montreal region who ice fish or open water fish.

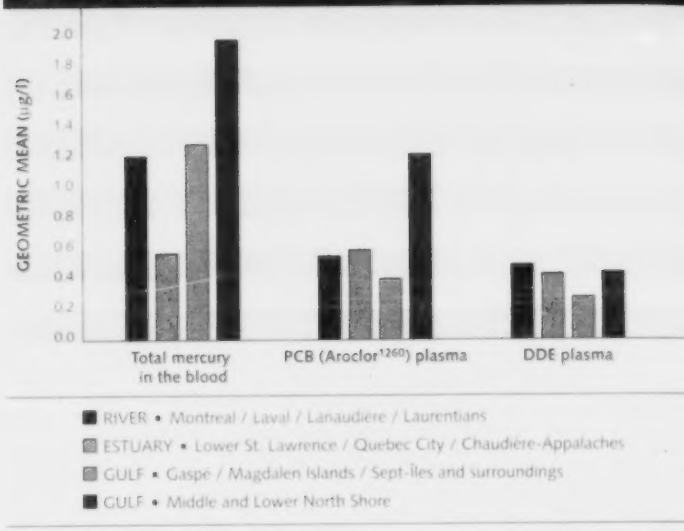
Data was collected over three fishing seasons: fall 1995, winter 1996 and fall 1996. A total of 3078 anglers were met over the three data collection seasons and 1654 were retained to participate in phase one of the study. Based on information collected, some individuals were invited to participate in a more exhaustive evaluation including a detailed food questionnaire and blood, urine and hair samples. A total of 80 fishers selected as high-level consumers of fish from the St. Lawrence and 55 fishers considered as low-level consumers participated in this second evaluation.

Mercury concentrations in the blood samples proved to be significantly higher among high-level consumers, although only one sample exceeded the Health Canada recommended limit. Average plasma PCB concentrations were also higher among high-level consumers than among low-level consumers. Six high-level consumers of fish from sport fishing exceeded Health Canada's guidelines for PCBs compared with only one in the other group. Chlorinated pesticide concentrations in plasma were detected in few fishers and were within safe levels established by the World Health Organization (WHO).

Analyses from this study conclude that even high-level consumers of fish don't show excessive levels of chemical contamination.

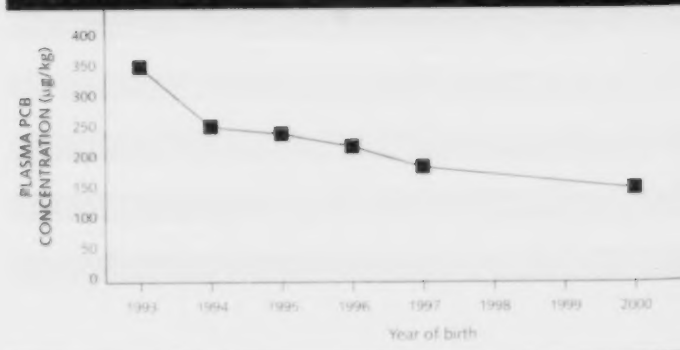
Concentrations of contaminants found in sport fishers are generally within acceptable levels.

LEVELS OF ENVIRONMENTAL CONTAMINANTS IN BLOOD TAKEN FROM THE UMBILICAL CORDS OF NEWBORNS IN DIFFERENT REGIONS ALONG THE ST. LAWRENCE[9, 10, 11]



Fetuses and infants breastfed by women who consume large amounts of fish represent groups that are indirectly and temporarily exposed more to organochlorines. One method of evaluating prenatal exposure to contaminants is analysis of umbilical cord blood at the time of birth. This also allows contaminant exposure assessment within the general population and in those groups at greatest risk. The results of three recent studies on newborns in Quebec indicate that the profile of contaminant exposure corresponds to the principal geographic regions of the St. Lawrence.[9, 10, 11]

EVOLUTION IN PCB* CONCENTRATIONS IN BLOOD TAKEN FROM THE UMBILICAL CORDS OF NEWBORNS IN THE MIDDLE AND LOWER NORTH SHORE[12]



* Sum of 14 congeners

On the Lower and Middle North Shore, organochlorine concentrations among newborns are higher on average than elsewhere in Quebec, although there has been a gradual decrease since 1993. For example, PCB concentrations measured during 2000 were about 2.5 times lower than those registered in 1993, or equivalent to the levels observed for Quebec as a whole between 1993 and 1995.[12] This decrease in plasma concentrations of PCBs may be associated with a decrease in the consumption of seabird eggs on the North Shore.

In summary, data currently available indicates that even among more highly exposed individuals, the contaminant concentrations measured are generally found to be within levels accepted by health organizations.

THE CASE OF THE EEL[13]

The American eel, a symbol of Great Lakes contamination and particularly of the insecticide Mirex, has long been considered unfit for human consumption. Analyses conducted in 1990 reveal that the PCB and Mirex concentrations are actually about three times less than that measured at the beginning of the 1980s and, for the most part, their concentration levels respect commercialization standards. In terms of eels found on the Quebec market, lab analyses are conducted to ensure the lots sent to wholesalers respect chemical contamination commercialization standards. However it is mainly in the Lower St. Lawrence that you can find eel in restaurants. The individual who chooses to eat a traditional boiled or smoked eel each fall runs no health risk.

ICE FISHING IN THE SAGUENAY FJORD[6]

From the end of December to the middle of March at least 5000 smelt and ground fish (redfish, cod and halibut) anglers fish on the ice of the Saguenay fjord. Exposure to contaminants by high-level fish consumers and an evaluation of the wholesomeness of species fished from this area in winter were estimated using historical data on this type of fishing, characterization of consumption habits of anglers, actual levels of contamination in the fish species most frequently fished and blood tests on 60 fishers.

Researchers observed that among consumers of fish from the Saguenay, mercury, PCB and organochlorine pesticide (particularly chlordane and hexachlorobenzene) impregnation significantly increased according to the frequency of fish consumption; however, levels attained were not considered problematic. Thus mercury impregnation seen at the end of the season does not surpass maximum acceptable levels, even among regular consumers of brook trout caught in peak season.

Generally speaking, PCB and organochlorine pesticide impregnation among high-level consumers of fish from the Saguenay is comparable to high-level consumers of fish from areas of Lake Ontario and the freshwater reaches of Mississauga, but remains below levels measured among anglers from the Montreal region.

Data on the whole leads to the conclusion that seasonal consumption of rainbow smelt, redfish and Greenland cod doesn't represent a health danger to the general public to the extent that ice fishers who also fish in summer respect the recommendations of *Guide de consommation de poisson de pêche sportive en eau douce* (Freshwater Fishing: Consumption of Fish).[5]

GEOMETRIC MEANS OF CONCENTRATIONS OF MERCURY, PCBs (AROCLOR[1260]) AND DDE IN THE BLOOD OF FISHERS FROM THE ST. LAWRENCE, AND RIVERSIDE POPULATION

REGION AND COLLECTION YEAR	POPULATION STUDIED	MERCURY [a] (µg/l, blood)	PCBs (AROCLOR[1260]) [b] (µg/l, plasma)	DDE [c] (µg/l, plasma)
Saguenay / Lac-Saint-Jean	High-level consumers	2.80	3.50	1.40
Winter 2000[6]	Low-level consumers (of fish from ice fishing in the Saguenay fjord)	1.30	2.50	1.20
Sept-Îles 1998	Non-native fishers	1.68	3.46	1.47
Uashat-Maliotenam 1998[14]	Native fishers (Montagnais)	2.06	4.73	1.91
Sept-Îles 1997[9]	General population (women 17 to 40 years old)	0.80	1.52	0.76
Montreal region Winter 1996	High-level consumers	3.53	4.33	1.54
	Low-level consumers	1.04	2.41	1.31
Fall 1996[7]	High-level consumers	2.64	6.60	2.44
	Low-level consumers	1.82	3.65	1.36
Quebec City region 1994[15]	General population (women 20 to 53 years old)	—	1.64	1.33
Lake Saint-Pierre Spring 1993[16]	Consumers	2.40	—	—
Lower North Shore 1990[17]	Commercial fishers and their spouses	5.40	35.20	8.70

[a] Guideline for mercury = 20 µg/l.[18]
[b] Guideline for Aroclor[1260] = 5 µg/l for women of child-bearing age and 20 µg/l for post-menopausal women and men.[18]
[c] Guideline for DDE = 200 µg/l.[18]

WHAT ARE THE RISKS ASSOCIATED WITH FISH ILLNESSES OR PARASITES?[19]

Most fish illnesses and parasites are non-transmittable to humans. However, some zoonoses caused by fish have been indicated. The most common illnesses seen in fish from the St. Lawrence are papilloma in the white sucker, lymphocystis, fibroma and fibrosarcoma in the walleye as well as parasitic cyst nodes on the skin and internal organs of several species of fish. The majority of fish parasites are found on the external organs (eye, fin, skin), in the abdominal cavity or in the internal organs. To completely eliminate contamination risks, throw out the fish's internal organs and skin before cooking and ensure that the fish is adequately cooked.

"EEL THING"[20]

"Eel Thing" or erysipeloid is a zoonosis caused by *Erysipelothrix rhusiopathiae* bacteria and normally associated with fisheries but also with agricultural production. The infection is mainly located on the hands and fingers where there are cuts, abrasions or stings from fish spines or bones and is sometimes accompanied by severely itchy skin. The redness that accompanies this disease is very pronounced and the infection has a tendency to spread. Healing occurs two to four weeks following antibiotic treatment.

CHRISTIANE CAGNÉ, HEALTH CANADA

WHAT ARE THE HEALTH BENEFITS OF FISH CONSUMPTION?

There are many nutritional benefits to consuming fish caught while sport fishing. Compared to meat, fish is generally lower in cholesterol and fat, especially saturated fat, and has equal levels of high-quality protein. Fish is also an excellent source of vitamins and minerals, including vitamin D and selenium, which is said to counteract the toxic effects of mercury.[21]

Consumption of fatty fish gives some protection against ischemic heart disease. This protection is attributed to omega-3 polyunsaturated fatty acids in fish.

Other preventive and therapeutic properties can also be attributed to omega-3 fatty acids, especially in women who are pregnant or who breastfeed their babies. These long-chain fatty acids are considered essential for child growth and development.

A study conducted in the Middle and Lower North Shore regions revealed that the proportion of omega-3 fatty acids in umbilical cord blood was higher among residents of the North Shore (6.3%) than in those of southern Quebec (2.0%). The study's authors indicate that consuming this type of fatty acid may be partly responsible for the fact that average birth weights along the North Shore are higher than those in Quebec as a whole.[17]

SOME PREVENTIVE MEASURES[23]

Fish should be properly gutted, washed and kept cold to maintain its freshness. If this common-sense advice is followed, occasionally eating a freshwater catch from sport fishing does not pose health risks. Regular consumers will not face health risks if they follow the following guidelines:

- Avoid eating the internal organs and skin;
- Limit yourself to four (4) portions of insect-eating fish (yellow perch, catfish, sunfish, sturgeon) per month;
- Limit yourself to two (2) portions of predator fish species per month (walleye, pike, bass, muskie).

Pregnant women should avoid eating species of fish for which consumption restrictions exist.

Most parasites occasionally found in fish are inoffensive and easily destroyed through cooking.

Fish consumption provides some protection against ischemic heart disease.

ST. LAWRENCE FOOD GUIDE[22]

The *St. Lawrence Food Guide* provides information about the nutritional and organoleptic quality of aquatic resources. It contains an analysis of 18 species of fish, four species of mollusks and three species of crustaceans from the River, estuary and gulf that are sold in supermarkets and fish markets in Quebec. The *St. Lawrence Food Guide* can be downloaded from the St. Lawrence Vision 2000 Action Plan Web site at: www.slv2000.qc.ca.

NUTRIENT LEVELS[a] IN SOME OF THE MOST FREQUENTLY CAUGHT SPECIES IN THE ST. LAWRENCE

	Protein (g)	Vitamin D (UI)	Selenium (mg)	Potassium (mg)	Omega-3 fatty acids (mg)
NUTRIENT BENEFITS	Forms antibodies; repairs body tissues	Absorbs calcium and phosphorous	Anti-oxidation properties; role in preventing cardiovascular diseases and cancer	Maintain the body's osmotic balance	Protect against cardiovascular and inflammatory diseases; brain development
Walleye	34	1 609	0.05	648	391
Smelt[b]	25	124	0.04	135	1 445
Mackerel[b]	31	796	0.09	594	9 537
Yellow perch	33	1 123	0.05	630	352
Trout[b]	35	572	0.04	630	3 282

[a] Per 180-gram (or 6-oz.) serving.
[b] Omega-3 fatty acid levels in smelt, mackerel and trout represent 100% of Canadian daily recommended amount.

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ST. LAWRENCE FOOD GUIDE[22]

The *St. Lawrence Food Guide* provides information about the nutritional and organoleptic quality of aquatic resources. It contains an analysis of 18 species of fish, four species of mollusks and three species of crustaceans from the River, estuary and gulf that are sold in supermarkets and fish markets in Quebec. The *St. Lawrence Food Guide* can be downloaded from the St. Lawrence Vision 2000 Action Plan Web site at: www.slv2000.qc.ca

NUTRIENT LEVELS * IN SOME OF THE MOST FREQUENTLY CAUGHT SPECIES IN THE ST. LAWRENCE

	Protein (g)	Vitamin D (UI)	Selenium (mg)	Potassium (mg)	Omega-3 fatty acids (mg)
NUTRIENT BENEFITS	Forms antibodies; repairs body tissues	Absorbs calcium and phosphorous	Anti-oxidation properties; role in preventing cardiovascular diseases and cancer	Maintain the body's osmotic balance	Protect against cardiovascular and inflammatory diseases; brain development
Walleye	34	1 609	0.05	648	391
Smelt	25	124	0.04	135	1 445
Mackerel	31	796	0.09	594	9 537
Yellow perch	33	1 123	0.05	630	352
Trout	35	572	0.04	630	3 282

* Per 180-gram (or 6-oz.) serving.

** Omega-3 fatty acid levels in smelt, mackerel and trout represent 500% of Canadian daily recommended intakes.

1.2 Harvesting mollusks

Mollusk harvesting is a popular recreational activity for coastal residents of the North Shore, Gaspé and Magdalen Islands. A study in 2002 of 1000 people from the Gulf of St. Lawrence indicated that close to 40% of residents have eaten mollusks harvested for non-commercial purposes and 27% have harvested mollusks from the banks of the St. Lawrence.

Soft-shell clams and mussels are most commonly harvested and consumed. Whelk, abalones, clams and scallops are some of the other mollusks harvested for non-commercial purposes. Slightly more than half (57%) of those who eat harvested mollusks take some precautions (harvesting solely in authorized areas, not eating mollusks that appear to be dead, using adequate cooking methods, etc.) to reduce the risks. Moreover, 40% of Gulf residents consider that consuming mollusks harvested for non-commercial purposes may be dangerous to one's health.[1]

According to a 1997 study of North Shore residents, the study's authors estimated that interviewees consumed an average of 15 mollusk meals per year and ate 410 grams (g) of mollusk meat per meal, equivalent to an average of 17 g per day. This amount is approximately 10 times greater than what the rest of Quebecers eat, which can be partially explained by North Shore residents' proximity to this resource.[24]

Mollusks represent an interesting food source for people. They constitute a significant source of protein and also contain vitamins and essential minerals such as selenium as well as omega-3 fatty acids. They are also relatively low in cholesterol and easily digestible.[25]

OVERVIEW OF NUTRIENT VALUES OF SOME MOLLUSKS FOUND IN THE ST. LAWRENCE [22]

	NUTRIENT LEVEL [a]				
	Protein (g)	Selenium (mg)	Iodine (mg)	Omega-3 fatty acids (mg)	Cholesterol [b] (mg)
Soft-shell clam [c]	24	0.14	0.49	675	86
Scallop	18	0.01	0.01	296	38
Mussel [c]	18	0.07	0.25	782	76
Oyster	16	0.07	0.25	432	61

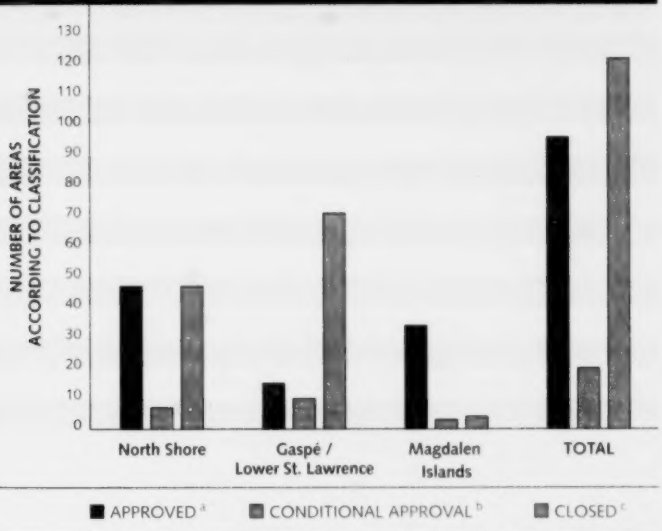
[a] Per 180-gram (or 6-oz.) serving.
[b] This proportion refers to a quantity (300 mg) which should not be surpassed on a daily basis.
[c] For selenium, iodine and Omega-3 fatty acids, levels present in clams and mussels correspond to 100% of the Canadian daily recommended amount.

Mollusks represent an interesting source of food for people.

ARE THERE RISKS TO CONSUMING MOLLUSKS?

In 2002, the Shellfish Water Quality Protection Program evaluated 238 shellfish areas. Of these, 116 areas were approved for mollusk harvesting, 96 permanently and 20 for part of the year. However, mollusks were considered unfit for consumption in 51% (122/238) of the evaluated shellfish areas of the St. Lawrence mainly because of fixed contamination by bacteria.[26] Over the course of the harvesting season, marine toxins from microscopic algae are sometimes added to the bacteriological contamination, which results in other site closures. There are also more than 100 areas which have never been evaluated due to problems accessing them or the low number of mollusks present.

DISTRIBUTION OF SHELLFISH AREAS BY REGION ACCORDING TO THE SHELLFISH WATER QUALITY PROTECTION PROGRAM CLASSIFICATION IN 2002



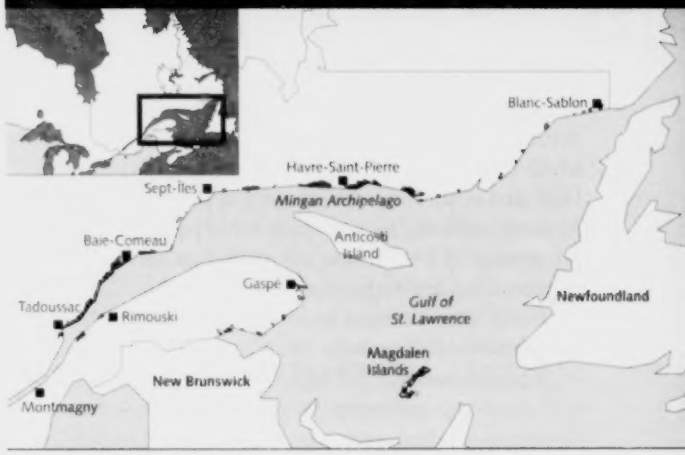
[a] Area that is normally open: bacteriological water quality standards are met at all times. Mollusk harvesting is permitted except if biotoxins are detected, in which case the area will be closed immediately.

[b] Area open with conditions: bacteriological water quality standards are met during a defined period of the year; mollusk harvesting is permitted only during this period. Biotoxin detection will lead to immediate closure.

[c] Permanently closed area: bacteriological water quality standards were exceeded or the presence of chemical contaminants or biotoxins exceeded the standards.

Adapted from: Sénéchal, J., 2002. *La salubrité des eaux coquillières – Fiche d'information*. Environment Canada, Environmental Protection Branch, St. Lawrence Vision 2000. 6 p.

MARITIME TERRITORY COVERED BY ENVIRONMENT CANADA'S SHELLFISH WATER QUALITY PROTECTION PROGRAM



Adapted from: Sénéchal, J., 2002. *La salubrité des eaux coquillières – Fiche d'information*. Environment Canada, Environmental Protection Branch, St. Lawrence Vision 2000. 6 p.

HOW CAN ONE BE SURE THAT A HARVEST SITE IS SAFE?[26, 27]

Environment Canada's Shellfish Water Quality Protection Program was established to determine the degree of bacteriological contamination of water at most shoreline shellfish harvesting sites. Indicators used are micro-organisms recognized as being associated with the presence of pathogenic agents. When the number of indicators surpasses a certain threshold, the mollusks are considered unfit for consumption and the areas are closed to harvesting. A program sponsored by the Canadian Food Inspection Agency monitors shellfish for biotoxin contamination. Results from these two monitoring programs are forwarded to Fisheries and Oceans Canada, which is ultimately responsible for opening or closing shellfish-growing areas. When a sector is closed, a sign is posted close to the access areas indicating that harvesting is prohibited. Inquiries about the condition at a site can also be made by contacting local Fisheries and Oceans Canada offices.

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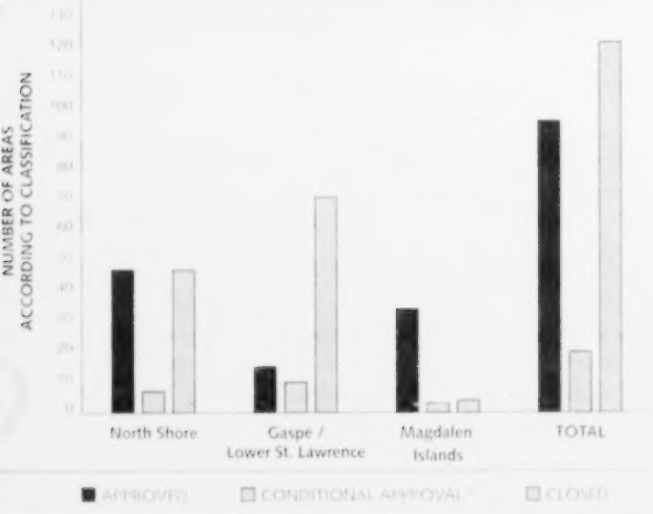

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WHAT DO WE KNOW ABOUT MOLLUSK CONTAMINATION?

CONTAMINATION VIA MICRO-ORGANISMS

Mollusks filter water to eat and are therefore susceptible to absorbing and accumulating various types of micro-organisms which exist in water, whether they are pathogens or not. Little data exists about the presence of micro-organisms in mollusks harvested for non-commercial purposes. A study in the summer of 1999 of nine soft-shell clam harvesting areas between Grandes-Bergeronnes and Pointe-aux-Outardes on the North Shore revealed new information about microbial contamination and mollusks. The most notable results indicated an increased frequency of detection of *Cryptosporidium* sp. and *Giardia* sp. pathogens in soft-shell clams as the most frequently detected organisms, followed by *Campylobacter* sp. However, high levels of contamination indicators (*Escherichia coli* and fecal coliform) were only detected in a small proportion of these contaminated samples. Other studies are necessary to validate results obtained. Indeed these results may be explained by the low sensitivity of the method used for counting bacteria and the effect of water salinity on the common indicators.[28]

POISONING CAUSED BY MOLLUSK CONSUMPTION[29]

A surveillance study of mollusk-related illnesses was conducted in Eastern Quebec from spring 1999 to winter 2001. A total of 48 poisoning episodes affecting 66 people were inventoried. An exhaustive analysis of the information collected for each case (symptoms, type of food consumed, blood and stool analyses, investigation report, etc.) was conducted to determine whether there was a link between the illness and mollusk consumption. Among the recorded episodes, 3 were classified as "confirmed", 30 "potential", 11 "[illegible]likely", and 4 "rejected". Two of the three "confirmed" episodes were of microbial origin and involved a bacterial pathogen (*Bacillus cereus* and *Clostridium perfringens*). The other episode concerned marine toxins (PSP). Close to 70% of the episodes classified as "confirmed" or "potential" were associated with consuming seafood from a restaurant, grocery store or fish market. Non-commercial harvesting was responsible for six episodes of poisoning (18%). Mussels are without a doubt the most frequent cause of these episodes (55% of cases), followed by whelk (15%) and soft-shelled clams (15%). In a 1997 study in the North Shore region, close to 8% of respondents said that they had become ill from eating mollusks.

BIOTOXIN CONTAMINATION

Mollusks are also capable of absorbing microscopic algae, some of which produce biotoxins, especially planktonic algae, *Alexandrium tamarense*.[30] These algae, found mostly in the lower estuary in summer and along the Gulf of St. Lawrence shoreline, multiply and concentrate according to various environmental conditions (temperature, variations in salt content, abundance of nutrient matter, currents).[31, 33]

Once contaminated, mollusks can maintain their toxicity from several weeks to several months. These toxins accumulate in the mollusk's internal organs and can cause various types of poisoning in those who eat them. The three most likely to occur in Quebec are paralytic shellfish poisoning (PSP), amnesiac shell fish poisoning (ASP) and diarrhetic shellfish poisoning (DSP).[32]

SYMPTOMS ASSOCIATED WITH PARALYTIC SHELLFISH POISONING, AMNESIAC SHELLFISH POISONING AND DIARRHETIC SHELLFISH POISONING[32]

	GENERAL SYMPTOMS	GASTROINTESTINAL SYMPTOMS	NEUROLOGICAL SYMPTOMS	LATENCY PERIOD	DURATION
Paralytic shellfish poisoning	headache, dizziness, weakness	vomiting, diarrhea, abdominal cramps, nausea	tingling or numbness around the lips gradually spreading to the face and neck and to the tips of the fingers and toes, stiffness and lack of coordination, impression of floating, slight difficulty breathing, rapid pulse, muscle paralysis, sensation of suffocating, convulsion, pronounced difficulty breathing, death from respiratory failure	less than 30 minutes to close to 1 hour after eating	4 to 5 days
Amnesiac shellfish poisoning	headache, dizziness, weakness	vomiting, diarrhea, abdominal cramps, nausea	loss of memory, mental confusion, disorientation, loss of balance, involuntary facial contorsions	normally 5 to 6 hours after eating, however can vary between 15 minutes and 38 hours	several days to several weeks
Diarrhetic shellfish poisoning	headache, dizziness, weakness	vomiting, diarrhea, abdominal cramps, nausea	none	30 minutes to 4 hours after eating	1 to 4 days

Mollusks from the St. Lawrence are filtering organisms which may contain pathogenic micro-organisms and biotoxins.

PSP is the most frequently experienced poisoning among those who eat mollusks from the St. Lawrence – the region of Canada that sees the largest number of such cases. Since 1984, at least 16 confirmed cases of PSP have been recorded. The last cases of ASP recorded in Quebec were in 1987 and were related to consumption of mollusks from Prince Edward Island. No cases of DSP have been reported in Quebec.[32]

In 1998 the unexpected discovery of new toxins in mollusks from the Magdalen Islands, particularly those that cause diarrhetic poisoning, alerted researchers from the Canadian Food Inspection Agency to measure the toxin in question in the digestive glands of mussels and other mollusks from various shellfish harvesting areas. Approximately 10% of samples were contaminated with diarrhetic toxins. Of these, 56% were taken from outside the Magdalen Islands, demonstrating that the contaminant first seen in the summer of 1998 existed in other harvest regions of Quebec. The occurrence of these toxins may have been caused by *Prorocentrum lima* algae, as was the case in mussels analyzed from elsewhere in Eastern Canada. Researchers also discovered *Prorocentrum mexicanum* from the same algae family. They had been previously unaware of its presence in the region, as it is normally found in more southern latitudes. They noticed that under certain environmental conditions these algae could be found in the digestive glands of cultivated mussels.[33]

CHEMICAL CONTAMINATION

A health risk evaluation regarding the occurrence of chemicals in mollusks was conducted in 1997 on the North Shore between Tadoussac and Baie-Trinité. The majority of known chemical contaminants were detected in the soft-shell clam samples. Exposure to chemical contaminants when consuming soft-shell clams was evaluated according to various consumption scenarios. The results indicated that chemical substances capable of causing threshold toxic effects, such as non-carcinogenic systemic effects, were not present in sufficient concentrations to create a risk for an individual eating a normal portion of soft-shell clams, even among regular consumers.[31]

Several cases of poisoning are recorded each year among mollusk harvesters.

SOME PREVENTIVE MEASURES[15, 33, 36]

- If you are harvesting mollusks yourself, ensure that you do so in open areas. Respect the restriction signs along the roads and in other harvest access areas.
- When in doubt about the status of a given area, contact the local Fisheries and Oceans Canada office before starting to harvest.
- Buy shellfish from a well-known retailer where fresh products are brought in regularly.

PRECAUTIONS AGAINST PATHOGENIC MICRO-ORGANISMS:

- Bivalve mollusks must be alive when purchased; throw out the ones that do not close when tapped, as they may be dead.
- Keep live mollusks in the refrigerator in a container covered with a clean, damp cloth and consume them within three days of harvesting.
- To steam mollusks, once the steam starts to form begin timing for 4 to 9 minutes; for boiled mollusks, wait 3 to 5 minutes after the shells open. Throw out any bivalves that do not open upon cooking.

PRECAUTIONS AGAINST TOXINS:

- Avoid harvesting Arctic wedge clams and razor-shell clams for consumption because they may contain biotoxins. Buy from the fish market instead.
- Remember that appearance, smell, colour and taste are not reliable indicators of poisonous mollusks and that cooking does not eliminate toxins.

INCREASING AWARENESS AMONG MOLLUSK HARVESTERS

ZIP committees from the north shore of the estuary, Bay of Chaleurs and the Magdalen Islands developed unique communication methods adapted to their individual environments to ensure that mollusk harvesters were well informed. Given the possibility of mollusk contamination via pathogenic micro-organisms and biotoxins, their message included the importance of following the preventive measures.

1.3 Hunting along the St. Lawrence

WATERFOWL HUNTING

The vast territory and abundance of game found along the St. Lawrence River each fall make this an exceptional hunting region. However, the number of waterfowl hunters has regularly declined since 1980. In 1999, slightly more than 30 000 hunting permits were sold, a 2.5-fold decrease from 20 years previous. Estimates from 1999 indicate that approximately 353 000 birds were hunted in Quebec during hunting season.[37] Close to 65% of the total take of migratory birds comes from the St. Lawrence. The American Black Duck, Mallard, Green-winged Teal and Snow Goose account for almost 50% of birds hunted.[2]

A dietary investigation study of migratory bird hunters in fall 1999 indicated that they consumed an average of 7.5 meals of waterfowl per year. Waterfowl consumption is highest in the Gulf region at 8.9 meals per year. Regional differences exist in terms of the consumption proportion of some species (see table below).[37]

DOES CONSUMING WATERFOWL PRESENT A HEALTH RISK?

At the end of the 1980s the Canadian Wildlife Service analyzed specimens gathered from across Canada. Overall, inorganic and organic contaminant concentrations measured in various samples were weak and often below the detection threshold. Moreover, the results indicated that dabbler ducks are generally less contaminated than diver ducks. Some samples from the St. Lawrence ecosystem surpassed the norms; it is difficult, however, to establish a link between contamination in the St. Lawrence and that of the waterfowl. Given fall migration, hunted birds may have come from a long distance away.

WATERFOWL CONSUMPTION BY SPECIES AND REGION IN 1999[37]

Number of respondents = n
Percentage of migratory bird hunters who are consumers = %
Average number of meals during the year = MEALS

	MONTREAL (n = 113)		LAKE SAINT-PIERRE (n = 97)		ESTUARY (n = 154)		GULF (n = 77)		TOTAL	
	%	MEALS	%	MEALS	%	MEALS	%	MEALS	%	MEALS
Geese	62.8	4.5	56.7	3.8	72.7	4.0	64.9	4.4	65.1	4.2
Dabbler ducks	90.3	5.4	92.8	4.5	84.4	4.3	76.6	4.0	86.8	4.6
Scaup[a]	27.4	2.4	20.6	2.3	7.1	1.8	14.3	2.0	16.4	2.3
Goldeneye	11.5	1.6	8.2	1.7	4.5	1.3	14.3	2.0	8.9	1.8
Sea ducks[b]	10.6	2.1	13.4	2.8	3.2	2.7	37.7	4.2	12.3	3.0
Goldeneye + Sea ducks	17.7	2.1	11.3	1.4	7.1	1.9	44.2	4.1	17.8	2.9
Merganser[c]	11.5	1.8	62.8	4.5	1.3	1.7	16.9	2.0	8.9	1.7
All species	94.2	8.1	93.2	6.7	93.3	6.8	92.8	8.9	—	7.5

[a] Previously known as tufted-ducks
[b] Scoters, oldsquaw, eiders
[c] Also commonly known in French Quebec as the "bec-scie"

While it is in decline, waterfowl hunting remains a popular activity among riverside residents.

To estimate health risks associated with consumption of waterfowl from the St. Lawrence, researchers evaluated hunters' exposure to various contaminants found in the birds. This risk analysis was undertaken based on information obtained during a species survey and the amounts consumed as well as contamination data compiled by the Canadian Wildlife Service. Researchers also integrated fish consumption into the exposure calculations. Estimates show that health risks relating to waterfowl consumption are probably negligible for the vast majority of hunters and that ingesting fish remains the principal source of exposure to chemical contaminants in the St. Lawrence. As a result, researchers have determined that it would not be justifiable to impose consumption rules relating to waterfowl taken from the St. Lawrence region.[38]

On the other hand, migratory birds, like all other living organisms, are susceptible to the development of certain diseases and to becoming hosts to parasites that can alter their health to varying degrees. Parasites found in ducks do not generally represent a threat to human health. Certain diseases caused by bacteria could, however, be transmitted to humans. Small amounts of muscle on the breast and the absence of fat beneath the skin are indicators of possible sickness in birds.[39]

Seal hunting is an activity that presents a number of dangers to inexperienced hunters.

HUNTING AMPHIBIANS[39]

Hunting amphibians (Leopard Frog, Bullfrog, and Green Frog) on the St. Lawrence has been a relatively popular activity, principally in the Lake Saint-Pierre region. However, catches have dropped off considerably mainly due to overexploitation of the resource. Results from tests conducted on Leopard Frogs from Lake Saint-Pierre revealed low levels of PCBs and Mirex, such that health impacts of consuming frog legs from this sector were considered negligible. The principal threat to human health related to contact with frogs actually comes from Red Leg, caused by *Aeromonas hydrophila* bacteria, which are transmissible to humans. An infected frog most notably presents ulcers on the skin, bloating of the abdominal area, and redness on the rear feet and lower stomach. The disease in humans manifests itself as gastroenteritis and localized infections of skin wounds. For preventive purposes, handling or consuming frogs showing signs of contamination is not recommended.

SEAL HUNTING

Seal hunting is an activity practised in the Gulf of St. Lawrence and its maritime estuary, especially the Magdalen Islands and the North Shore. In these areas, catches are limited mainly to one species, the Harp Seal. For example, in 2001, 18 641 Harp Seals were caught on the Magdalen Islands, the most intense region of seal hunting, while on the North Shore the number rose to 600. The success of this type of hunting is strongly influenced by weather conditions, especially in the Magdalen Islands, where the hunt is practised mostly on ice fields.

Until recently, there was very little data available concerning the consumption of seal meat. A study conducted among hunters from these two regions reached close to 50% of the hunting population. These people consume close to 10 grams per day, of which a certain quantity is offal. Due to their geographic location, seal hunters have similar access to other marine resources, including fish, mollusks, and crustaceans. This natural proximity translates into a general consumption of seafood that is seven times that of the Quebec population as a whole.[40]

DOES THE CONSUMPTION OF SEAL MEAT PRESENT A HEALTH RISK?

Like many marine mammals, seals are found in the upper reaches of the food chain. As a result, the concentrations of many persistent contaminants (e.g. PCBs or DDT) in their fatty tissues and livers may become relatively high. Data analysis of exposure to certain heavy metals and organochlorines, drawn from a number of seal hunters, indicates a relationship between consumption of offal and flesh and concentrations of organochlorines. Compared to PCB data obtained among other populations, concentrations among seal hunters were higher than concentrations in major consumers of fish such as white fish from the Saguenay or fish from the Great Lakes, but lower than major consumers of fish in the Montreal area. No seal hunters tested showed PCB and mercury levels higher than those recommended by health organizations.[39]

WHAT ARE THE BENEFITS?

Seafood consumption is a known good source of omega-3 fatty acids.[22] Levels of fatty acids found in seal hunters, who also consume large quantities of fish, mollusks, and crustaceans, are at least three times as high (6%) than those measured among all Quebecers (2%). These levels actually approach those found among the Inuit (8%). Dietary preferences for certain species of fish rich in fatty acids could provide an explanation for the levels observed.[40]

Seal hunting is primarily practised in the Magdalen Islands and on the North Shore. Catches are limited mainly to one species, the Harp Seal.

NUTRITIONAL VALUE OF LIVER FROM THE HARP SEAL[40]

One 4-ounce (113 grams) portion of seal liver provides more than 100% of the recommended daily intake of vitamins A and D, iron, zinc, and selenium, close to 90% of the recommended intake of magnesium, and 40% of that for protein. This same portion also supplies just over 60% of the recommended intake of fatty acids, in this case, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).

WHAT ARE THE DANGERS ASSOCIATED WITH SEAL HUNTING?

Seal hunting and the handling of the catch involve a certain number of risks to the health and safety of hunters. They are the natural risks most often mentioned by the hunters themselves, in particular, factors associated with the movement of ice (wind, currents, tides, etc.)

Health and safety problems most frequently experienced by hunters are sunburns, which affect 25-40% of hunters; falls into water, to which 20-30% of hunters fall victim; back injuries due mainly to transporting heavy loads in difficult conditions, suffered by 15% of hunters; and chilblain, which affects approximately 10% of hunters. Following these are hand infections (8% of hunters), bites and scratches (6%), and transportation accidents (4%).[40]

SEAL FINGER[41]

Seal Finger is a zoonosis which is acquired following bites or through the handling of various marine mammal carcasses which carry the pathogen, particularly the seal. The infection often enters the skin via a scratch or a cut. The agent responsible for Seal Finger has not yet been isolated.

The degree of inflammation varies, but it can cause the finger to swell up to three times its normal size, accompanied by severe shooting pain and increasing stiffness of the joints close to the site of infection. Seal Finger heals slowly if left untreated, with complete recovery generally taking a period of three to four months. Today, Seal Finger can be effectively treated with the tetracycline antibiotic.

1.4 Other St. Lawrence food sources

The St. Lawrence contains other resources that can be eaten by riverside residents. These include crustaceans and, to a lesser degree, seaweed.

CRUSTACEANS

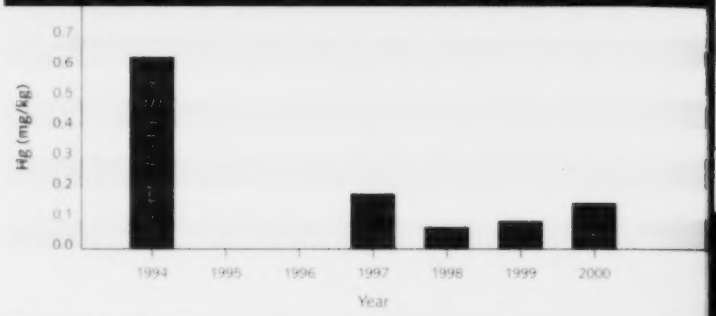
The main crustaceans harvested from the St. Lawrence are the Northern Lobster, Snow Crab, Northern Shrimp, and crayfish. The Northern Lobster and Snow Crab are classified among the most significant commercial species and the most sought-after foods from the Gulf. The Northern Shrimp is found in abundance in the Gulf and in the estuary of the St. Lawrence while crayfish can be caught everywhere in Quebec but mainly in Lake Saint-Pierre.[42]

WHAT DO WE KNOW ABOUT THE PRESENCE OF CONTAMINANTS IN CRUSTACEANS?

Data produced by a contaminant tracking program undertaken in the early 1990s by Fisheries and Oceans Canada indicated low concentrations of metals in crustaceans from the estuary and the Gulf. For the group of species studied, mercury content was low, with the exception of Northern Shrimp and Snow Crab from the Saguenay fjord. In fact, these two species continue to have mercury contents approaching the established limit for commercialized fish products, though there was a decrease in the concentrations observed between 1994 and 1997. This situation is attributable to massive mercury contamination of the fjord's sediment from the early 1970s, when concentrations measured among shrimp exceeded 10 mg/kg.

In terms of organochlorines, levels observed in the musculature are generally low for the crustacean group.[43] The available data concerning contamination of crayfish flesh comes from samples taken from Lake Saint-Pierre in the 1980s. The information reveals that, at that time, crayfish experienced little contamination by chemical substances and mercury. PCBs and Mirex levels were below amounts deemed acceptable for commercialized fish products.[39]

TEMPORAL EVOLUTION OF MERCURY CONTAMINATION IN SNOW CRAB OF THE SAGUENAY FJORD



Adapted from: Lebeuf, M., M. Noël and Y. Clermont. 2002. *La contamination des ressources marines par les toxiques – Fiche d'information*. Fisheries and Oceans Canada, Maurice Lamontagne Institute, St. Lawrence Vision 2000. 6 p.

Finally, contaminants have a tendency to accumulate in the hepatopancreas of crustaceans (commonly referred to as the "green liver"). Exposure can be significantly decreased by not consuming this part of the animal.[39, 44]

WHAT NUTRITIONAL VALUE DO CRUSTACEANS PROVIDE?

As with mollusks, crustaceans present very significant nutritional value; they are excellent sources of protein, vitamins, and mineral salts, all while being low in fat.

OVERVIEW OF THE NUTRITIONAL VALUES OF THE ST. LAWRENCE'S PRINCIPAL CRUSTACEANS[22]

NUTRIENT LEVELS[a]

	Protein (g)	Selenium (mg)	Iodine (mg)	Omega-3 fatty acids (mg)	Cholesterol[b] (mg)
Crab[c]	22	0.15	0.21	412	79
Shrimp	39	0.03	0.03	141	86
Lobster[c]	25	0.10	0.93	399	57

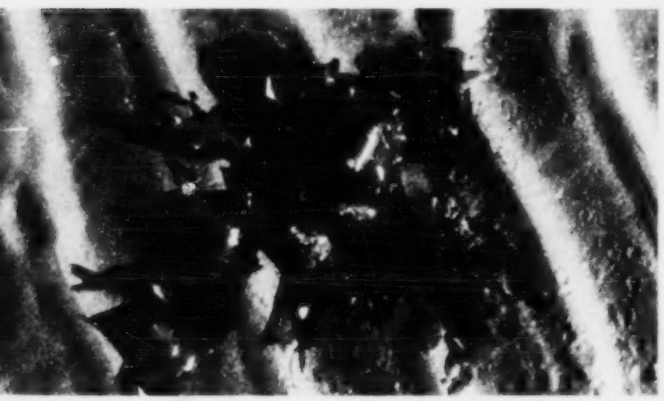
[a] Per 120-gram cooked portion.
[b] Represents the proportion of the daily amount (300 mg) that should not be exceeded.
[c] With respect to selenium and iodine, the levels present in crab and lobster correspond with 100% of the recommended daily intake in Canada.

MARINE BIRD EGGS

There are areas of the Gulf of St. Lawrence where the springtime collection of eiderdown and seagull eggs is a tradition in certain riverside communities. Studies have shown PCB levels in Herring Gull eggs to be 14 times as high as those measured in cod liver and 200 times as high as those found in seal flesh.[45] Therefore, consumption of seagull eggs raises the body's load of organochlorines to high levels, as shown in certain studies conducted among people on the Lower North Shore.[13]

EDIBLE SEAWEED

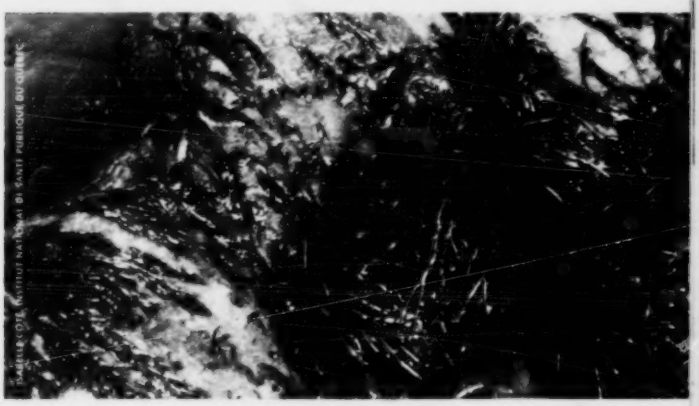
In contrast to many Asian countries, harvesting seaweed for consumption in Quebec remains a marginal activity. In fact, while the consumption habits of riverside residents are little known in this area, it seems, according to a Quebec study, that only 0.14% of Quebecers eat seaweed —despite the fact that many species readily available in the St. Lawrence estuary, including kelp and dulse, are edible.[46, 38]



CAN SEAWEED BE CONSUMED WITHOUT RISK?

Studies conducted on seaweed taken from the maritime estuary, the Gulf, and Bay of Chaleurs revealed that contaminant levels were generally very low, often below detectable levels in the case of organochlorine compounds (PCBs and pesticides) and mercury. Except for cadmium, concentrations of metals were similar to those found elsewhere in the world in both polluted and unpolluted areas.[47]

Concentrations of iodine are elevated in certain species of seaweed. Iodine contents that are too high can cause problems with the functioning of the thyroid gland. It is therefore recommended that regular seaweed consumers stick to species lowest in iodine (e.g. sea lettuce, dulse, laver, etc.). The iodine level in seaweed can also be reduced by soaking it and cooking it in water.[48] In general, the consumption of seaweed presents no notable risk to human health.



WHAT DO WE KNOW ABOUT THE NUTRITIONAL VALUE OF SEAWEED?

Seaweed consumption can provide a significant supply of iron, fibre, and vitamins A and B_{12} – the latter is rarely present in fruits and vegetables. Protein proportions vary between 5 and 30% of dry weight, depending on the type of seaweed, which is comparable to that found in garden vegetables. Dietary fibre in seaweed is found in equivalent or even greater quantities than that of fruits and vegetables.[47, 49]

2 Activities in and on the water

2.1 Swimming and water sports

The St. Lawrence was once a popular destination for swimming. However, it has gradually fallen out of favour due to the closure of numerous beaches that were highly polluted and significant social changes like the privatization of riverbanks, diversification of leisure activities, urban expansion, and improved access to swimming pools. Swimming nevertheless remains fairly popular in certain salt water areas of the St. Lawrence as well as upstream from Montreal. In 2002, 9% of the riverside population – close to 268 000 people – reported swimming in the St. Lawrence. Though this number includes those who practise water-based activities such as windsurfing, water-skiing, and scuba diving, the vast majority of these people went to the St. Lawrence to cool down or to swim.[1]

The popularity of swimming in the St. Lawrence varies greatly, however, from region to region depending on the weather, quality of the water, ease of access, or the lifestyles of local people. For whatever reason, residents of the Gulf region (over 27% of the population) swim the most in the St. Lawrence.

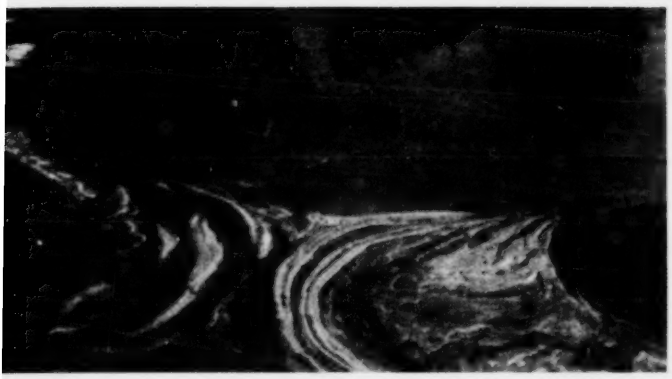
According to this survey, more than half of riverside residents (58%) estimate that health risks associated with swimming in the St. Lawrence are high, a decrease from the results of a study conducted in 1995 (65%). However, the percentage of people who consider the risks to be non-existent also declined, dropping from 3% in 1995 to less than 1% in 2002. Moreover, it seems that approximately one in three (36%) would swim in the St. Lawrence if they were informed that the quality of the water was good for swimming.[1, 50]

There has been no research to date demonstrating that very low concentrations of chemical contaminants in natural swimming waters could pose a health risk to occasional swimmers. However, the presence of certain micro-organisms (bacteria, viruses, protozoa, or other parasites) in these waters has long been considered a risk factor for the development of various health problems.

In Quebec, the monitoring of natural swimming water quality is ensured by the *Ministère de l'Environnement du Québec* through the *Environnement-Plage* program. To be admitted to the program, a beach must be operating for the purposes of swimming, be accessible to the public, and be acknowledged as safe. The owner-operator of the beach is required to inform the clientele by installing a sign that indicates the last sampling date and the bacteriological quality rating of the water. The municipality itself has the responsibility of prohibiting access to beaches when waters are judged to be unhealthy.[51] In 2002, over 400 public beaches were admitted to the program, including 10 on the St. Lawrence. Of these, five were located in salt water, mostly in the Gaspé, and five in fresh water, around the height of Lake Saint-François.[52]

SEAGULLS: A THREAT TO THE QUALITY OF BEACHES?[53, 54]

The ring-billed gull, a common bird along the St. Lawrence, is a carrier of several micro-organisms pathogenic to humans, including *Salmonella, Aeromonas, Campylobacter, Pseudomonas, Yersinia* and *Staphylococcus*. Thus, it is possible that health problems could develop should efforts not be maintained to limit the presence of these birds on beaches. Moreover, studies conducted in the freshwater section of the St. Lawrence have shown that through their excrement, seagulls can contribute to the microbiological contamination of recreational waters. The authors of these studies recommend limiting food sources near swimming areas to avoid attracting seagulls. Clean beaches, covered garbage containers, and prohibiting the feeding of birds are all simple steps that should prevent these types of problems.



CYANOBACTERIA BLOOMS (BLUE-GREEN ALGAE[b])[55]

Cyanobacteria are aquatic organisms that most often grow in areas where the water is calm and motionless, relatively warm, and rich in phosphorus. When prevalent on the surface, cyanobacteria can form a mass called an algae bloom that, in certain cases, resembles green or turquoise paint spilled into the water.

Cyanobacteria are interesting from a public health perspective in that they can produce toxins. Certain types, if ingested, can cause damage to the liver (hepatoxins) or the central nervous system (neurotoxins), while other components can irritate the skin (endotoxins). Certain recreational activities (swimming, windsurfing, water-skiing, etc.) can involve skin exposure or accidental ingestion of water.

The presence of cyanobacteria and toxins (neurotoxins and hepatoxins) was researched in the watersheds of three St. Lawrence River tributaries, the Assomption, Châteauguay and Yamaska rivers. Results revealed that the risk was low for the watersheds studied but nevertheless indicated a presence of significant concentrations of cyanobacteria in the swimming areas on Waterloo and Brome lakes in the Yamaska drainage basin. At certain times, the abundance of cyanobacteria found was considered sufficient to pose a risk to people doing recreational water-based activities. However, results of the study should be interpreted as a selective portrait of the conditions that may be encountered in these waters.

[b] *In French, this is commonly translated as "Algues bleues"*

WHAT ARE THE RISKS RELATED TO SWIMMING IN CONTAMINATED WATERS?

When swimming in waters contaminated by pathogenic micro-organisms, involuntary ingestion of water can, for example, provoke gastro-enteritis. Introduction of micro-organisms into the auditory canal can cause otitis externa, contact with the mucous membrane of the eye can result in acute conjunctivitis, and contact with an open wound can lead to a localized infection or provoke non-specific symptoms like a fever. Certain micro-organisms can also affect a specific organ, as in the case of Hepatitis A, whereby the virus affects mainly the liver. The delay between exposure and appearance of symptoms varies from a few hours to a few days to as much as a few weeks, depending on the micro-organism involved.

Furthermore, the pathogenic power of a micro-organism varies depending on different factors such as the host's susceptibility. It is usually young children who, due to their behaviour and their sensitivity to infection, are most at risk when swimming in micro-organism-polluted water.

Until now, no swimming-related epidemics in the St. Lawrence have been reported, although various epidemiological surveys conducted among riverside residents have confirmed that swimming in polluted areas has the potential to induce health problems. For example, increased medical consultations for otitis externa were observed and associated with periods of swimming activity on Lake Saint-François.[56]

SWIMMER'S ITCH

Swimmer's Itch (or Cercarial Dermatitis) is a benign ailment that occasionally arises during swimming season in some of Quebec's bodies of water. The larvae of a parasite called Cercaria attach themselves to the skin and cause various types of discomfort such as red blotches and itchiness in the hours and days following contact with the water. Humans are exogenous hosts, as they do not allow the parasite to complete its life cycle. The ailment does not have significant after-effects among the majority of infected people. The presence of Cercaria in swimming waters is associated with the presence of aquatic birds and snails essential to the parasite's life cycle. There is no exhaustive data on the proportion of birds and snails that are infected but studies conducted in certain swimming areas of Quebec have demonstrated that up to 50% of some species of snail can be carriers of the parasite.[57] Each year, numerous cases of Swimmer's Itch, arising mainly in lakes, are reported to Quebec public health services.[58]

ARE THOSE INVOLVED IN WATER SPORTS ALSO AT RISK?

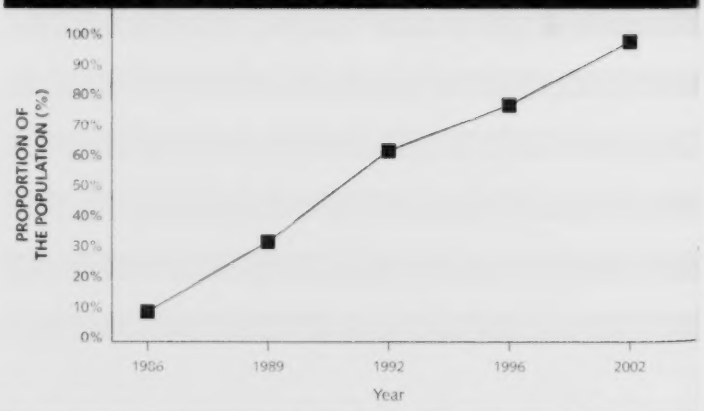
Water sports enthusiasts who windsurf, water-ski, scuba dive, or do other water activities are also at risk. A study conducted during a popular celebration that consists of bodysurfing the Richelieu River's rapids in a wetsuit revealed that participants were susceptible to developing benign infections associated with swimming in polluted waters. The authors of the study also reported a link between the incidence of diarrhea and the number of descents by participants. Skin rashes were also reported by approximately 8% of people wearing wetsuits, as opposed to dry suits.[59] An earlier study conducted during a windsurfing competition in the Quebec City region revealed that the risk of contracting an infection increased with the number of falls into the water. Beginners, who fall in more frequently, were therefore more susceptible to infection.[60]

WHAT DO WE KNOW ABOUT THE QUALITY OF POTENTIAL SWIMMING SITES ALONG THE ST. LAWRENCE?

For a number of years, improvements have been noted in the bacteriological quality of the St. Lawrence in a variety of locations. This progress is in part due to the efforts of riverside municipalities, especially between 1978 and 1995, to initiate treatment of their wastewater. Today, almost all Quebecers (98.9%) served by municipal sewers have their wastewater treated at a treatment plant.[61] However, the bacteriological quality of the water at St. Lawrence beaches still has not reached desired levels, mostly due to overflow from the municipal sewers during periods of rain and the failure by some municipalities to disinfect their effluents.[62] The role of other pollution sources in the microbiological contamination in the St. Lawrence, particularly runoff in urban and agricultural areas, remains difficult to quantify.[63]

A study conducted in 1995 indicates that the development and use of beaches along the freshwater section of the St. Lawrence varies widely from one area to another.[36] Some are used by only a handful of people while others, like those in Saint-Thimothée and Cap-Saint-Jacques near Montreal, draw over 40 000 bathers through the summer season. In the saltwater section of the St. Lawrence, Tadoussac, Grandes-Bergeronnes, Les Escoumins and Pointe-Lebel are very popular on the North Shore as are Trois-Pistoles and Saint-Luce on the South Shore.[36]

EVOLUTION OF THE PROPORTION OF RIVERSIDE POPULATIONS SERVED BY A WASTEWATER TREATMENT FACILITY[61]



The bacteriological quality of the water at a beach can vary significantly over the course of a summer.

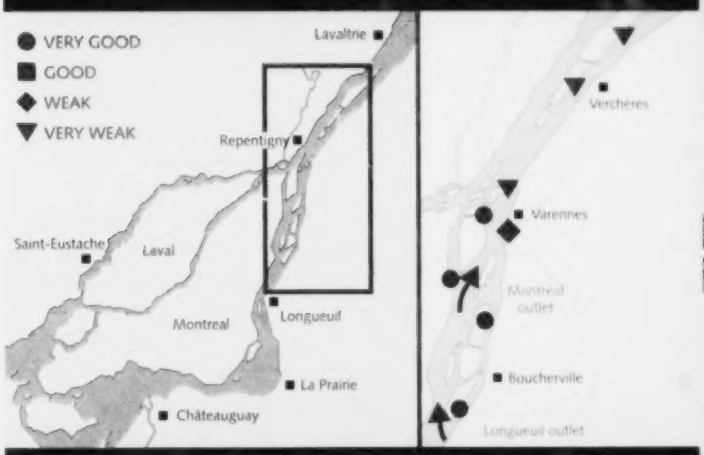
Over the course of several summers the *Ministère de l'Environnement du Québec* monitored the bacteriological quality of various potential swimming sites along the St. Lawrence. The sites were selected according to diverse criteria: historic beaches, formerly monitored beaches, areas actually being used, availability of public access, aesthetic qualities, and overall potential. This process indicated that, during the summers of 1999, 2000, and 2001, 54%, 39%, and 34% of the sites sampled offered significant swimming potential. The study also provided evidence of a link between precipitation and bacteriological contamination of the water, demonstrating the importance of meteorological factors in local contamination of river waters.[64, 65, 66]

With the help of a mathematical model, researchers attempted to determine the quantity of precipitation necessary to surpass safe swimming limits at Île Saint-Quentin (Trois-Rivières). In doing this, they highlighted the importance of closing the beach to the public for a 24-hour period on the day following a significant rainfall, specifically one in excess of 10.5 mm. The results of this study have reinforced the importance of allowing for a certain delay between untreated wastewater overflow and the reopening of swimming sites.[67] Close observation of the quality of swimming sites will help in evaluating fluctuations.

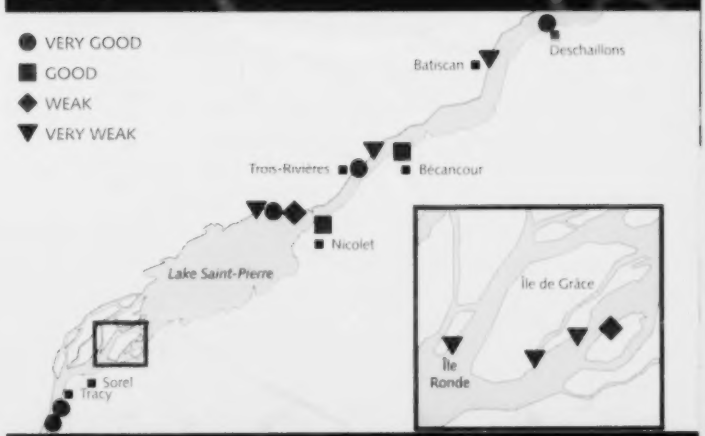
There are many locations along the St. Lawrence where water quality is very good for recreational activities.

Since 1999, the City of Montreal has carried out bacteriological analyses of the waters surrounding the shores of the Island of Montreal, Île Jésus (which includes Rivière des Prairies), Île Bizard, Lake Saint-Louis, the La Prairie basin, the Port of Montreal, and Rivière des Mille-Îles on the South Shore. In 2001, eight rounds of sampling were conducted between June and October. While numerous samples recorded from Rivière des Prairies exceeded safe swimming criteria, the results indicated an excellent bacteriological quality in the waters of Lake Saint-Louis and the La Prairie basin.[68]

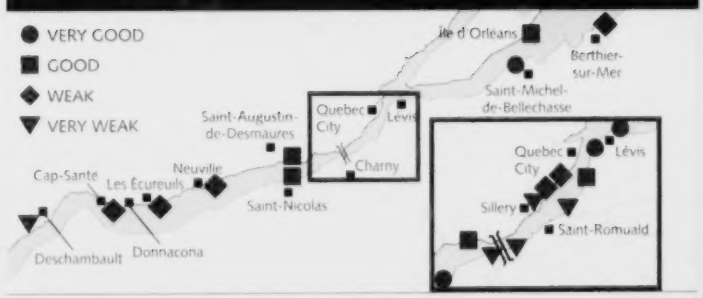
SWIMMING POTENTIAL IN THE MONTREAL REGION
1999-2001[64, 65, 66]



SWIMMING POTENTIAL IN THE LAKE ST. PIERRE REGION
1999-2001[64, 65, 66]



SWIMMING POTENTIAL IN THE QUEBEC CITY REGION
1999-2001[64, 65, 66]



A site was considered to have significant potential for swimming when the potential was considered good or very good.
The potential of a site is considered **very good** if swimming is possible 70% or more of the time and if the geometric seasonal average corresponds to an excellent bacteriological quality rating (Class A: fecal coliform 0 to 20/100 ml) or good (Class B: 21 to 100 fecal coliform/100 ml).
The potential of a site is considered **good** if swimming is possible 70% or more of the time and if the geometric seasonal average corresponds to a poor bacteriological quality rating (Class C: fecal coliform 101 to 200/100 ml).

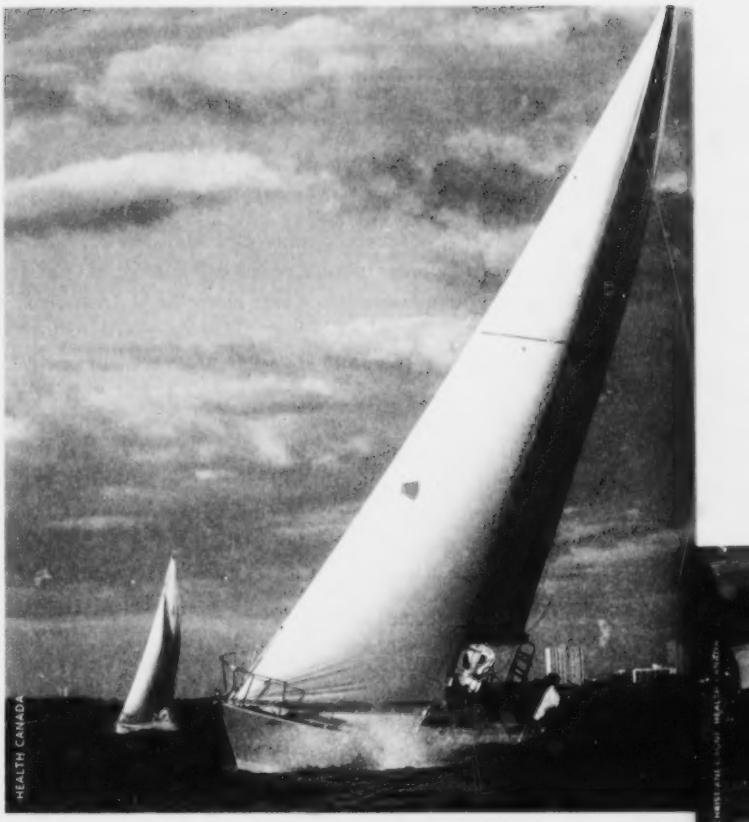
In summary, bacteriological evaluations conducted in a variety of locations along the St. Lawrence seem to indicate that many of them offer very acceptable conditions for water-based recreational activities. However, discharges of untreated wastewater, overflow water from municipal sewers and water treatment plants in times of heavy rain, the high number of seagulls and ducks, and periods of hot weather and heavy traffic are all factors that can rapidly affect the microbiological water quality. This is why water quality at a beach can vary substantially over the course of one summer. In this context, regular bacteriological analysis provides one method of establishing whether the water in one area presents a health risk to its users.

SAFETY DURING WATER-BASED ACTIVITIES

In 2002, 60% of bathers used a public beach on the St. Lawrence but only 27% swam where there was a lifeguard.[1] However, certain areas pose well-known safety risks due to dangers such as currents or eddies. Moreover, numerous deaths due to drowning occurred in areas without lifeguards.

Pleasure cruising on the St. Lawrence is enjoyed by over 500 000 riverside residents (17.5%), the majority of whom use motorized craft. Given the size of the waterway, its unique physical characteristics (currents, tides, frequent fog, winds, etc.), and the presence of a commercial shipping lane, boating on the St. Lawrence may present safety risks that cannot be ignored.

A 2002 survey indicated that lifejacket use varies greatly from one type of boat to another. Those who most often wear them are in sailboats or rowboats.[1] Furthermore, 25% of pleasure craft operators have already taken a course on water safety. This number should increase in future as a result of new requirements under the Canada Shipping Act's Competency of Operators of Pleasure Craft Regulations.



WATER LEVELS: A CONCERN AND AN IMPETUS FOR CHANGE[1]

In 2002, a significant proportion of riverside residents in cities (14%) and the river corridor (23%) were affected in varying degrees by dropping water levels in the St. Lawrence. Being in closer contact with the St. Lawrence, its users (swimmers, pleasure craft operators, and fishers) were more aware of variations in the rate of flow and the level of the water.

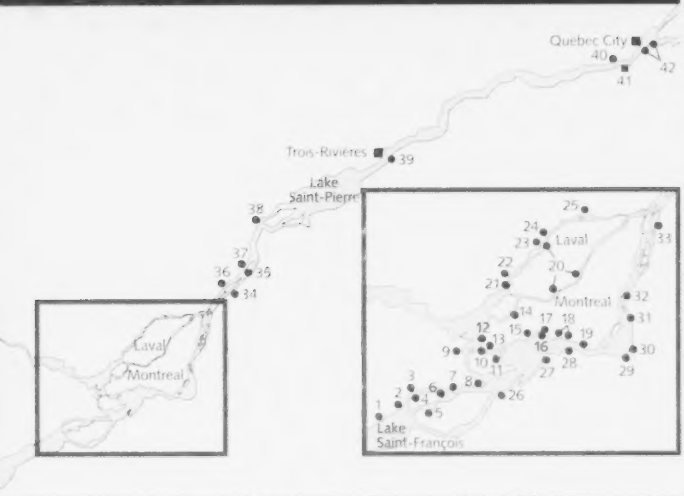
The main impacts felt by residents along the River were deterioration in the quality of the water, access problems, restrictions on pleasure cruising, and infringements on the integrity of the local marine environment or of nature in general. The one-third of riverside residents who were personally affected by dropping water levels would take various steps to react or adapt to the situation. These actions are numerous and respond to many areas of concern (changing areas where activities take place, adapting a boat, etc.), but the primary reported action seems to be a voluntary reduction in water consumption.

3 The drinking water supply

3.1 The consumption of drinking water

One of the most important uses of surface water is, without a doubt, drinking. In Quebec, slightly over 2.9 million individuals (approximately 39% of the population) are supplied with drinking water that comes partially or completely from the St. Lawrence River. Approximately 1.8 million of these people live in the Montreal area.[69]

MUNICIPALITIES WITH DRINKING WATER INTAKES IN THE ST. LAWRENCE



1. Saint-Zotique
2. Les Coteaux
3. Coteau-du-Lac
4-6. Salaberry-de-Valleyfield
7. Les Cèdres
8. Pointe-des-Cascades
9. Vaudreuil-Dorion
10. L'Île-Perrot
11. Notre-Dame-de-l'Île-Perrot
12-19. Montreal
20. Laval (three intakes)
21. Deux-Montagnes
22. Saint-Eustache
23. Sainte-Thérèse
24. Rosemère
25. Terrebonne
26. Beauharnois
27. Châteauguay
28. Kahnawake
29. Candiac
30. La Prairie
31-32. Longueuil
33. Varennes
34. Verchères
35. Contrecoeur
36. Saint-Sulpice
37. Lavaltrie
38. Berthierville
39. Bécancour
40. Quebec City
41-42. Lévis (two intakes)

Adapted from: St. Lawrence Centre. 1997. "The St. Lawrence River – Municipalities With Drinking Water Intakes (1995)", in *The River at a Glance*. (Environment Canada – Quebec Region. Info-Flash on the state of the St. Lawrence River). 6 p.

According to a survey conducted in 2002, residents along the St. Lawrence are, on the whole, largely satisfied (76%) with the taste of the water that they consume, whether it comes from an aqueduct or a private well. Moreover, the majority of residents (87%) estimate that the health risks of consuming tap water are low or even very low. Similarly, two thirds (66%) of them frequently drink tap water, while the other third mainly drink bottled water.[1]

CAN TREATED WATER CONTAIN PATHOGENIC MICRO-ORGANISMS?

While index organisms provide a reliable method of monitoring fecal microbial contamination, certain pathogenic agents present in water can pass undetected. Possible explanations for this phenomenon include the low quality of untreated water, not maintaining optimal treatment conditions, micro-organisms resistant to treatment, or even infiltration of the distribution network. The main organisms likely to give rise to infectious diseases following ingestion of water are viruses, bacteria, and protozoa.

A series of studies was conducted on bowel diseases arising among populations of the Montérégie's watersheds. These studies revealed most notably that the rates of incidence of salmonellosis, campylobacteriosis, pseudotuberculosis, and giardiasis, as well as hospitalization rates for giardiasis, enteritis, viral gastro-enteritis, and other poorly defined enteric diagnoses are significantly higher among residents of the Yamaska River when compared to the entire Montérégie. These bowel diseases were associated with various risk factors. Furthermore, despite the weak degree of association obtained, a certain proportion of *Giardia* sp. and *Campylobacter* sp. infections could have been attributable to consuming tap water, given the population's frequency of exposure.[71]

One of the most important uses of surface water is undoubtedly for drinking.

In certain conditions, untreated water drawn for consumption purposes can contain cyanobacteria, also called blue-green algae, which is capable of producing toxic substances. A study to evaluate the presence of a few of these substances, most notably microcystins, was conducted in drinking water treatment plants located in the Yamaska River watershed and in the portion of the Assomption River downstream from Joliette. The results did not show a significant risk relating to toxin concentrations in either the raw or the treated water. The strongest concentrations of microcystins in treated water were at least 100 times below Health Canada's guidelines.[35]

WHICH MICRO-ORGANISMS ARE MOST RESISTANT TO DISINFECTION?

Giardia and *Cryptosporidium* protozoa receive the most attention from public health workers because they can survive for long periods in the environment and, as a result, can provoke outbreaks of gastrointestinal infection. During water treatment, these are the organisms that are the most difficult to eliminate. An adequate filtration system ensures the most efficient elimination.

In Quebec, as in the rest of Canada, giardiasis, a persistent gastrointestinal illness stemming from *Giardia* protozoa, is the most commonly reported parasitic infection[72] and the third most frequent intestinal illness requiring compulsory notification. The main symptoms of giardiasis, which normally appear one to three weeks after ingestion of the parasite, are persistent diarrhea, abdominal cramps or pain, nausea, and flatulence. *Cryptosporidium* causes similar symptoms, but the illness that it provokes, cryptosporidiosis, can also give rise to chronic problems among immunodeficient individuals.

A study has already reported the presence of *Giardia* and *Cryptosporidium* in the untreated water, and in lesser quantities in the treated water, of certain Canadian municipalities.[72] In the St. Lawrence's case, *Giardia* and *Cryptosporidium* protozoa have been found in weak concentrations in almost 90% of untreated water samples taken from drinking water treatment plants in 45 municipalities drawing water from the St. Lawrence and some of its tributaries.[73]

MONITORING WATER-BORNE ILLNESSES

Epidemiological studies on the human health impacts of microbial contamination of the St. Lawrence and its tributaries are rare. The Quebec public health network's system of compulsory notification for certain illnesses is the main monitoring tool for specific water-borne illnesses. Although it permits declared cases to be recorded, this system does not permit identification of the mode of transmission of catalogued cases. There are also problems of under-reporting and undiagnosed cases, such that only a fraction of water-borne illnesses are detected.[74] More flexible and current tools and mechanisms have been developed and the effects of their implementation should be gradually seen in the coming years.

The risk factors associated with giardiasis among riverside residents in the central and eastern regions of Quebec have been examined through a case-control study. Travelling in a high-risk country was the main risk factor among adults. Other significant factors for this group were camping, drinking untreated water while doing outdoor activities, and changing diapers. Among children, consuming tap water considered at risk[c] for external contamination was the only significant risk factor for acquiring this illness. For this age group, it seems that filtering drinking water is not sufficient to absolutely ensure giardiasis transmission is prevented. The fact that the consumption of at-risk water is not a factor for adults is likely due to an acquired immunity to Giardia. The results indicate that no significant association can be established between the illness and the consumption of treated water coming from the St. Lawrence.[75]

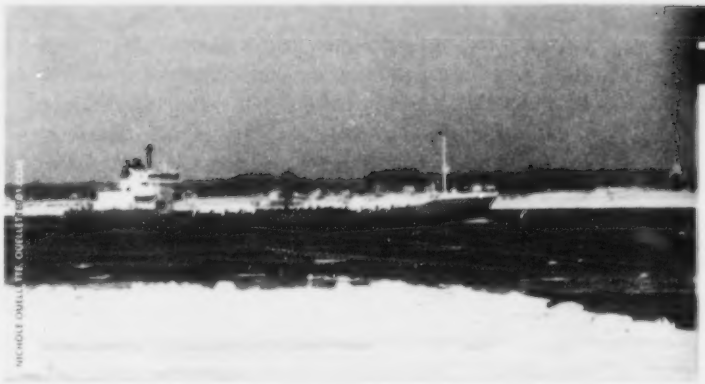
Giardia and Cryptosporidium are among the pathogens that require the greatest attention from public health workers.

[c] In this study, at-risk water was defined as unfiltered surface water or untreated surface well water.

IS THERE CAUSE FOR CONCERN ABOUT CHEMICAL CONTAMINANTS IN WATER FROM THE ST. LAWRENCE?

Chemicals continue to be dumped in the St. Lawrence River. However, many of these substances become less concentrated through dilution or because they are broken down by chemical and biological processes. The least water-soluble chemical substances are generally the most persistent. They tend to be adsorbed onto small particles suspended in the water and therefore only a very small proportion of these contaminants is dissolved. Following treatment, water taken from the St. Lawrence thus contains negligible concentrations of chemical contaminants.[76]

Certain chemical contaminants have recently become the focus of particular attention. This is the case with nonylphenol ethoxylates, surface-active agents currently used in large quantity as industrial or domestic detergents, as well as a vast array of solvents and pesticides. Given their extensive usage, significant quantities of nonylphenols are expelled into surface waters each year. Nonylphenol ethoxylates, and in particular the intermediate products resulting from their breakdown, are toxic to fish and other aquatic organisms. In addition, several in vivo studies provided evidence of estrogenic activity in these substances similar to certain alkylphenols that are considered endocrine disruptors. A recent study monitored these substances in raw and treated water from 11 drinking water treatment stations. In light of the concentrations measured and on the basis of a risk assessment, it appears that drinking water provides negligible human exposure to nonylphenols, even with concentrations higher than those measured in this study.[77]



THE POSSIBILITY OF CHEMICAL SPILLS IN THE ST. LAWRENCE: A THREAT TO THE SUPPLY OF DRINKING WATER?

In addition to being an important source of Quebec's drinking water, the St. Lawrence is a major artery for world maritime transportation and one that remains navigable throughout the year all the way to Montreal. Over 10 000 commercial vessels pass through annually, carrying up to 100 million tons of all types of merchandise.[78] Many Canadian and foreign vessels that navigate this challenging route transport substantial quantities of petroleum and chemical products.

Although major spills in the St. Lawrence have been infrequent up to this point, accidents that have happened elsewhere in the world encourage prudence. The eventual consequences on public health of a chemical product spill, particularly followed by contamination or an interruption in the supply of drinking water, require that emergency services have a plan.

A guide for action focusing on the issue of real or feared contamination of the drinking water supply in the case of a major spill was prepared within the framework of the Human Health Component of SLV 2000. Directed mainly at public health managers, this guide was originally conceived to improve the preparation level of relevant authorities, but it can also be useful during various emergency situations where the drinking water supply is disrupted or threatened.[79]

CAN CHLORINATING WATER CONSTITUTE A HEALTH RISK?

The *Regulation respecting the quality of drinking water* stipulates that surface waters, whether from the St. Lawrence or other sources, must be subjected to treatment, specifically continuous filtration and disinfection. Chlorination is a disinfection method with several advantages: in addition to acting as a disinfectant, it removes colour from the water, precipitates iron and manganese, and contributes to high quality water throughout the distribution network.

Chlorine added during treatment reacts with organic matter present in raw water. This reaction produces substances that can be toxic to humans, commonly referred to as chlorination by-products. The most common of these by-products are trihalomethanes (THM). Chloroform is the most frequently found and the most abundant in drinking water; this substance is actually considered a probable carcinogen in humans.[80]

Several epidemiological studies conducted in Canada and elsewhere have shown that the probability of developing cancer of the bladder, the colon, or the rectum was slightly higher among populations that consume chlorinated water than among those that drink nonchlorinated water. In the Great Lakes region, an estimated 10% and 13%, respectively, of bladder and colon cancers are attributed to the consumption over a 30-year period of chlorinated surface water containing trihalomethane concentrations of over 50 micrograms per litre (µg/l).[81]

Through an ecological epidemiological study researchers tried to verify geographic variations in incidences of the main cancer sites (stomach, colorectal, pancreas, lung, bladder, kidney, etc.) for the period from 1989 to 1993. The results indicated that cancer rates are no higher for those municipalities that draw drinking water from the St. Lawrence than for those that use another source of drinking water. Rates of bladder cancer in men and women, however, are slightly higher in municipalities that use chlorination, compared with those that use other treatment methods.[82]

Chlorination has many advantages as a method of disinfection.

WHAT ARE THE OTHER MAIN DISINFECTANTS USED?

In order to remedy the problems of chlorination, some riverside municipalities use ozonation as the main disinfectant in treating their water. However, because ozone breaks down quickly, small amounts of chlorine are still required to ensure continuous disinfection as the water circulates in the distribution network. Ozone-treated water also contains by-products that may pose a health threat, like bromate and aldehydes.

Other disinfectants, including chlorine dioxide, are possible alternatives to chlorine for treating drinking water. In addition to being a very efficient disinfectant and to improving the taste of the water, chlorine dioxide also has the advantage of considerably reducing the production of trihalomethanes. However, its toxic effects and its by-products – chlorites and chlorates – require more study, particularly among very young children.[83]

An exploratory study was conducted to verify whether red blood cells and thyroid function among nursing infants were affected by prenatal exposure (during pregnancy) or postnatal exposure (in the first weeks of life) to chlorine dioxide and its by-products. Overall, results were reassuring as all blood tests were normal for nursing infants who drank water disinfected with chlorine dioxide. However, a slight increase in the blood levels of thyroid stimulating hormone (TSH) among one group of infants raised some questions, particularly with respect to possible links to chlorine dioxide exposure. According to the authors, the clinical significance of this slight increase remains uncertain and does not likely have any physiological consequences.[83]

THE *REGULATION RESPECTING THE QUALITY OF DRINKING WATER*: AN IMPROVEMENT IN PUBLIC HEALTH PROTECTION

The *Regulation respecting the quality of drinking water*, adopted in 2001 by the Government of Quebec, establishes some of the most stringent standards and controls in North America. The Regulation's main objective is to improve public health protection. Among all the quality standards are requirements to analyze 17 inorganic substances and 42 new organic substances. Drinking water must be free of fecal coliform bacteria, *Escherichia coli*, as well as enterococcus bacteria and coliphage viruses. The Regulation also specifies that the treatment process used must allow for the elimination of at least 99.9% of *Giardia* cysts and 99% of *Cryptosporidium* oocysts. When fecal coliform or *Escherichia coli* are present, the Regulation requires distribution system owners to issue a boil-water advisory to all people affected in order to prevent ingestion of contaminated water. It also requires operator certification to ensure that they possess the necessary credentials.[84]

TRIHALOMETHANES (THM)

According to the Regulation, managers of distribution systems that distribute chlorine-treated water must ensure that their water is sampled four times per year to control trihalomethanes. Results obtained from these samples between summer 2001 and winter 2003 showed that THMs in water distributed by municipalities drawing from the St. Lawrence were, for the most part, present on a yearly pool average in concentrations below the new Quebec standard of 80 mg/l.[85] In recent years many riverside municipalities have implemented measures to reduce levels of chlorination by-products to as low a level as possible without impeding the effectiveness and the reliability of disinfection.

The Regulation respecting the quality of drinking water, *adopted in 2001, establishes standards and controls that are among the most stringent in North America.*

EXPOSURE TO CHLOROFORM RESULTING FROM SHOWERS AND BATHS[86]

Chloroform is the most abundant compound of the trihalomethanes family found in drinking water and is among the most volatile of chlorination by-products. Using hot water for baths and showers can cause an increase in the chloroform concentration in the air inside a house, causing chloroform exposure to its inhabitants through inhalation or through the skin.

During a study conducted among Quebec City area residences that receive water from the St. Lawrence or one of its principal tributaries, researchers measured chloroform concentrations in the surrounding air and the alveolar air for adult and child occupants before and after a shower or a bath. The authors of the study concluded that health risks linked to this exposure were negligible.

Progress in research on the effects of some environmental pollutants

As outlined in previous sections, St. Lawrence riverside residents and users may be exposed to environmental contamination in the river, which varies according to the nature of the contact, its intensity, duration, etc. In Quebec, as elsewhere in the world, research partially aims to measure and clarify the health effects of exposure to environmental chemical contaminants. The following text offers an overview of the results of recent studies on the subject.

EFFECTS ON THE IMMUNE SYSTEM[87]

The immune system is the target of a multitude of environmental chemical substances that are foreign to an organism. These substances may act on components of the immune system, interfering with its protective role. Among the chemical pollutants in the environment, several organochlorines have immunosuppressive properties that generally reduce resistance to bacterial and viral infections. A Quebec study revealed that susceptibility to otitis media was associated with prenatal exposure to organochlorines among Inuit children in Quebec's Far North. The source of exposure among mothers and their children was a bioaccumulation of organochlorine from the aquatic food chain, especially seal and beluga fat, which this population traditionally consumes in great quantity. Another study of newborns from the Lower North Shore established correlations between PCB plasma concentrations and secretion inhibition of some inflammatory cytokines.

While somewhat piecemeal, immunotoxicology research reveals that numerous environmental molecules are able to alter natural and specific immunity, bringing health risks for individuals and populations. Possible consequences include an increase in the incidence of infections, allergies and cancer. Little data exists to confirm the human health impact of environmental exposure to immunotoxic agents.

EFFECTS ON THE NERVOUS SYSTEM

In some regions of Quebec, traditional diets may include large quantities of fish and even sea mammals at certain times of year. Some substances that can contaminate organisms may lead to neurotoxic effects, as is the case with mercury and polychlorinated biphenyls (PCBs).

Effects attributable to prenatal exposure to PCBs include low birth weight and size, abnormally slow reflexes, poor muscle tone, reduced activity level and poor response to environmental stimuli.[88] Health problems related to mercury are mainly associated with exposure to its organic form, methylmercury (MeHg). MeHg is absorbed by the digestive tract and distributed throughout the body, particularly to the brain, where it can remain for a long period of time.

It can cross the placenta in pregnant women, penetrate the fetus and accumulate there. Prenatal exposure to organic mercury can harm development of the central nervous system and lead to retarded psychomotor development in children.[89] Neurological and developmental retardation in babies exposed to MeHg *in utero* has also been found.[23] However, the effects of prenatal exposure to an average concentration of mercury (measured in the mother's hair) of between 10 and 20 µg/g among fish-consuming populations in different areas of the world are still contradictory.[88]

CANCER AND THE ENVIRONMENT[90, 91]

Cancer is the second most frequent illness found in industrialized countries, surpassed only by cardiovascular disease. Eating habits and tobacco use have an important role to play, with their risk factors estimated at 35% and 30% respectively. Environmental factors may cause up to 10% of cancer. Among them, sunlight is associated with carcinomas often found on exposed body parts, as well as with skin melanomas and lip cancer. Various pollutants found in the surrounding air (asbestos, benzene, some polyaromatic hydrocarbons) and in drinking water (arsenic) are known human carcinogens.

In terms of drinking water, a large number of epidemiological studies associated elevated levels of bladder and rectal cancer with various chlorination by-products found in disinfected surface water, without having established a clear causal relationship.

HORMONE DISRUPTORS: SOME HYPOTHESES[92]

According to several researchers, some chemical substances in the environment may modify endocrine gland functioning by imitating the action of endogenous hormones. These products are grouped together as hormone disruptors. These substances include organochlorine pesticides (e.g. DDT), some phthalates, and alkylphenols, dioxins and their associated products.

The main avenues currently being explored concern *in utero* exposure to substances with estrogenic properties that may lead to the development of certain cancers (breast, prostate, testicular) and have an effect on reproductive functioning such as endometriosis, fertility problems and modified sexual behaviour. Delayed learning and problems of the immune system and thyroid function are also suspected outcomes.

Conclusion

The variety of work conducted within the framework of the Human Health Component since 1993 has focused on identifying potential sources of exposure to chemical and biological contaminants in the St. Lawrence, including eating mollusks, fish and seaweed, swimming and water sports, and drinking treated water from the River. The results of this work have allowed us to determine the health risks associated with contaminant exposure in its various forms.

EXPOSURE TO CONTAMINANTS

Since work began under the Human Health Component, knowledge of riverside residents' exposure to contaminants in the St. Lawrence has progressed considerably. We now have an overall profile of their exposure and a better identification of high-risk groups.

The principal source of exposure to persistent contaminants, and the best documented, is eating products coming from the St. Lawrence. Close to 10% of the riverside population enjoys recreational fishing. Studies confirm that fishers are exposed to persistent contaminants, although the levels are low and vary, depending on the source of the catch, the species fished, and the quantity of fish consumed. Mollusk harvesting, done mainly by residents in regions of the North Shore, the Gaspé, and the Magdalen Islands, represents an important dietary resource for these people. Eating this shellfish involves possible exposure to certain pathogenic micro-organisms and biotoxins, but exposure is greatly reduced when harvesters respect preventive measures. Furthermore, among the reported incidents of poisoning, very few were related to non-commercial harvesting on the St. Lawrence.

Activities in or on the St. Lawrence whereby people come into direct contact with the water, like swimming, windsurfing, or personal watercraft use, are practised by approximately 9% of the riverside population. Bacteriological evaluations conducted in various locations along the St. Lawrence show that several sites offer good potential for this type of activity. Some studies confirm, however, that people who swim in polluted locations are exposing themselves to various infections caused by pathogenic micro-organisms. With respect to cyanobacteria observed in certain tributaries of the St. Lawrence, they are not present in sufficient density to represent a specific health risk.

More than one third of the Quebec population is supplied with municipal drinking water drawn from the St. Lawrence. The quality of this treated water is good and it generally respects the *Regulation respecting the quality of drinking water* requirements. Disinfection by-products remain an issue, although concentrations seem to have diminished over the course of recent years. Very few epidemics of water-borne illness caused by the St. Lawrence or one of its tributaries have been reported to Quebec public health authorities.

HEALTH RISKS

The studies conducted on public health risks under the Health Component have helped to fuel scientific debate, and a number of questions remain unanswered regarding the types and degrees of risk associated with exposure to persistent contaminants in the aquatic ecosystem of the St. Lawrence.

The studies conducted to date reveal that the general public is exposed to a relatively low level of contaminants and that consumption in moderation of fish, mollusks, or seaweed from the St. Lawrence presents no health risk as long as current recommendations are respected. However, certain sub-groups, such as newborns nursing from women who consume a lot of fish and riverside residents who consume a large quantity of various aquatic resources, are more exposed to the contaminants present in the St. Lawrence and should therefore be the focus of further study. Even among these groups, current knowledge does not provide direct evidence of observable clinical effects. Information campaigns to counsel against certain risky behaviours have already been implemented.

With respect to swimming, the microbiological risks remain even though no epidemics relating to swimming in the River have been reported. However, the various epidemiological studies conducted among riverside residents confirmed that engaging in recreational activities in the polluted sections of the St. Lawrence can cause health problems not unlike those found in polluted bodies of water. On the whole, the St. Lawrence is not an aquatic environment favourable to the proliferation of cyanobacteria due to its strong currents and discharge. However, these organisms can grow in sheltered areas that are rich in phosphorus.

The quality of drinking water from the St. Lawrence must satisfy some of the most stringent standards in North America, which helps improve public health protection. Nevertheless, certain pathogenic agents present in untreated water such as *Cryptosporidium* and *Giardia* can sometimes resist treatment or even pass undetected. The results of recent studies reveal no significant associations between incidences of giardiasis and drinking treated water coming from the St. Lawrence or its tributaries. Microcystins are present in some drinking water networks but at concentrations at least 100 times below Health Canada guidelines. Drinking water disinfected with chlorine dioxide could cause a slight increase in concentration of a thyroid-stimulating hormone in the blood stream of very young children but this slight alteration probably has no physiological consequences.

RISK PERCEPTION

Public perceptions play an important role in the popularity of sport fishing on the St. Lawrence and on the consumption of fish caught. There is a need to distribute specific information detailing the risks and to clarify the significance of safety measures based on recommended fish consumption limits.

Most riverside residents perceive a high health risk associated with swimming in the St. Lawrence, which deters many people from participating in such activities. This situation could change, however, if monitored swimming areas begin operating on the St. Lawrence.

On the whole, riverside residents are satisfied with the taste of the water they consume and the majority of them estimate that the risk of consuming tap water is insignificant.

Studies show that the low popularity of recreational activities on the St. Lawrence is linked to the River's bad reputation. It is important to pursue studies on the real state of the St. Lawrence and health issues associated with its various uses and to publicize these results.

OUTLOOK TOWARDS THE FUTURE

The St. Lawrence offers great potential for a variety of uses even if that potential seems partly limited due to lack of confidence on the part of the population. However, the effect of contamination in the St. Lawrence on riverside populations remains a very complex question. Investments in research and monitoring must continue to better determine the nature and extent of the real risks. Similarly, a watershed-based global management approach constitutes a promising avenue for the St. Lawrence's rehabilitation and improvement. One of the probable consequences of climate change will be a significant variation in water levels of the St. Lawrence. A close monitoring of the evolution of the impact of these variations on the river's resources and affected populations must be undertaken.

Pursuing research on the health of the St. Lawrence and the people who live along its shores and public disclosure of new knowledge on the subject are essential to revitalizing our link to this ecosystem.

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